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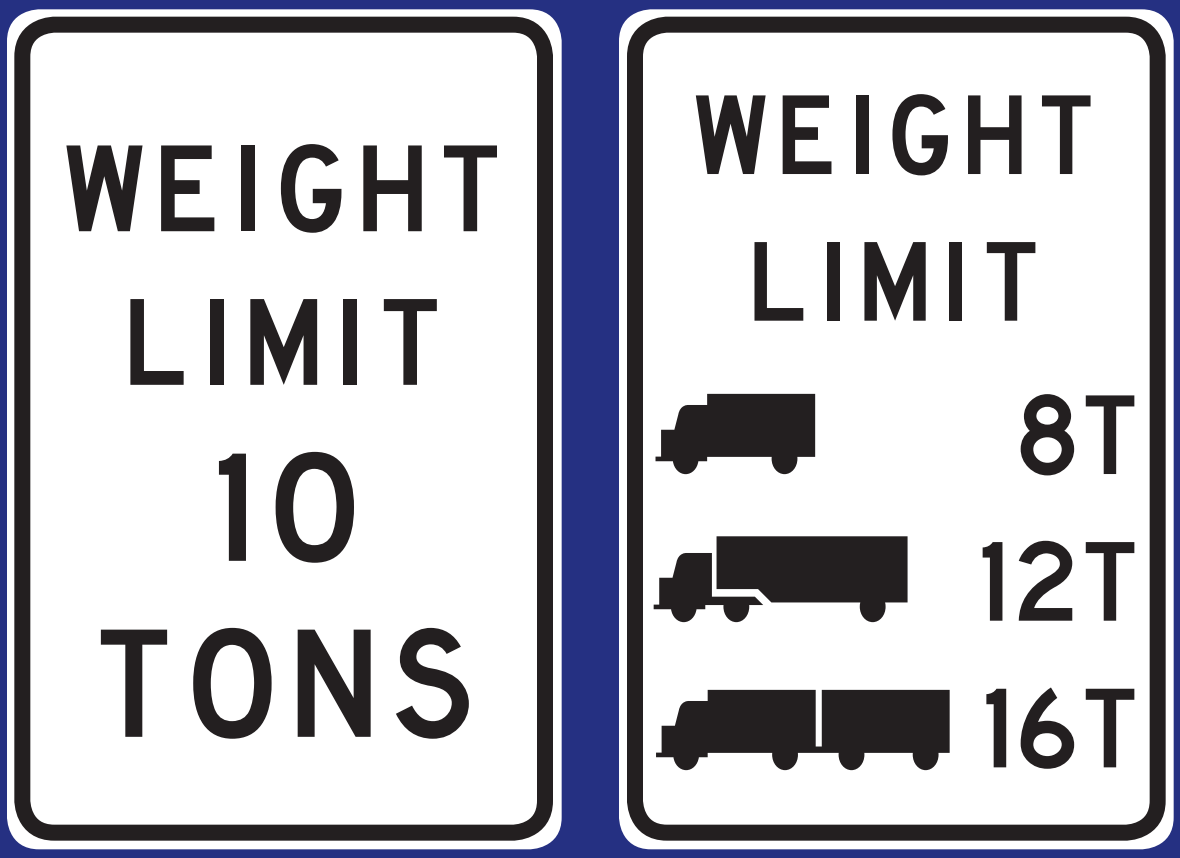
INDIANA DEPARTMENT OF TRANSPORTATION
AND PURDUE UNIVERSITY

Review of Load Rating and Posting Procedures and Requirements



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16. Abstract

All states are required to load rate and post bridges in order to comply with federal standards. Load ratings are performed in order to determine the safe live load capacity of a bridge, considering the existing conditions of the bridge. Based on the load ratings, the bridge is evaluated for load posting or strengthening. The Indiana Department of Transportation (INDOT) was notified that their practice for load rating and posting did not satisfy 23 CFR 650.313. The purpose of this study was to summarize and compare load rating and posting procedures used in other states and to provide recommendations and information necessary to modify the load rating and posting procedures in INDOT's Bridge Inspection Manual (Part 3: Load Rating) in order to satisfy 23 CFR 650.313.

In order to understand how load rating and posting is performed in other states, department of transportation (DOT) manuals were examined, questionnaires were sent to states, and additional states of interest were surveyed. The American Association of State Highway and Transportation Officials (AASHTO) The Manual for Bridge Evaluation, Second Edition, which is the current specification for load rating and posting bridges was reviewed, as well as older AASHTO bridge evaluation manuals. Based on this information, revisions were proposed to the INDOT Bridge Inspection Manual (Part 3: Load Rating) in order to eliminate current deficiencies.

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EXECUTIVE SUMMARY

REVIEW OF LOAD RATING AND POSTING PROCEDURES AND REQUIREMENT

Introduction

All states are required to load rate and post bridges in order to comply with federal standards. Load ratings are performed to determine the safe live load capacity of a bridge while considering the existing conditions of the bridge. Load posting or strengthening is determined based on the load ratings.

The Indiana Department of Transportation (INDOT) was notified that its practice for load rating and posting did not satisfy 23 CFR 650.313, which states that bridges shall be load rated and posted according to an American Association of State Highway and Transportation Officials (AASHTO) manual. The purpose of this study was to summarize and compare load rating and posting procedures used in other states and to provide recommendations and information necessary to modify the load rating and posting procedures in INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) in order to satisfy 23 CFR 650.313.

To understand how load rating and posting is performed in other states, we examined department of transportation (DOT) manuals, sent questionnaires to various states, and surveyed additional states of interest. We also reviewed AASHTO's *The Manual for Bridge Evaluation, Second Edition* (*MBE, 2nd Edition*), which is the current specification for load rating and posting bridges, as well as older AASHTO bridge evaluation manuals. With this information, we proposed revisions to the INDOT *Bridge Inspection Manual* (Part 3: Load Rating) to eliminate current deficiencies.

Findings

The information we collected on load rating and posting included, but was not limited to, the AASHTO manual used for load rating and posting, application of allowable stress rating (ASR), application of load factor rating (LFR), application of load and resistance factor rating (LRFR), legal vehicles, and posting signage. On the basis of our review of the information collected, we concluded the following:

- The majority of states are using the AASHTO *MBE, 2nd Edition*, which is the current specification for load rating and posting bridges.
- Many states are not using the ASR method for load rating and posting of bridges. Most states that are using the ASR method are only using the method for select applications.
- Almost all states prefer or accept both the LFR method and the LRFR method for load rating and posting of bridges.
- It appears that the few states that are currently not using the LRFR method plan to use the method in the future.
- The majority of states are using the AASHTO prescribed legal loads, or similar state variations of these loads, for load rating and posting of bridges.

Implementation

We recommend that INDOT take the following actions:

- Adopt the current AASHTO *MBE, 2nd Edition,* and subsequent interims and clearly state how to use this document.
- Use the AASHTO prescribed legal loads, or similar state variations of these loads, in load rating and posting.
- Adopt the load posting requirements prescribed by the AASHTO *MBE, 2nd Edition,* replacing the current posting procedures. This may, in some instances, result in the repair or closure of existing bridges that presently require posting.

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1. INTRODUCTION

All states are required to load rate and post bridges in order to comply with federal standards. Load ratings are performed in order to determine the safe live load capacity of a bridge, considering the existing conditions of the bridge. Bridges are load rated for design loads and legal loads. The design load ratings are required to be reported to the National Bridge Inventory (NBI) on a regular basis. Based on the legal load ratings, the bridge is evaluated for load posting or strengthening (AASHTO, 2011). Bridges may need to be posted for restrictive loads when the capacity of the bridge decreases and/or when the demand on the bridge increases. The capacity of the bridge may decrease due to deterioration, damage, etc. The demand on the bridge may increase due to changes in the dead load (bridge deck, wearing surface, etc.) or the live load (legal trucks, permit trucks, or special loadings). While load rating is an engineering activity, load posting is an economic activity (AASHTO, 2011). A posted bridge may create a severe restriction on traffic near the bridge. On the other hand, choosing not to post a bridge may create safety issues. Due to these reasons, it is important that load rating and posting analysis is performed correctly.

The current specification for load rating and posting bridges is *The Manual for Bridge Evaluation, Second Edition* (*MBE, 2nd Edition*) (AASHTO, 2011), developed by the American Association of State Highway and Transportation Officials (AASHTO). Bridges may be evaluated using any of three methods: allowable stress rating (ASR), load factor rating (LFR), and load and resistance factor rating (LRFR). The AASHTO *MBE, 2nd Edition*, Section 6B discusses safety criteria and procedures for the ASR and LFR methods (AASHTO, 2011). The AASHTO *MBE, 2nd Edition*, Section 6A discusses the LRFR method, which provides uniform reliability in bridge load ratings, load postings, and permit decisions (AASHTO, 2011). Under each of these methods, bridges are rated for design and legal live loads, and then evaluated for posting or strengthening based on the legal live loads.

The Indiana Department of Transportation (INDOT) was notified that their practice for load rating and posting did not satisfy 23 CFR 650.313, which states that bridges shall be load rated and posted according to an AASHTO manual. Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently provides little guidance on load rating and posting procedures. Although the manual covers load rating and posting methods, legal loads, and posting requirements, it lacks the necessary details required for proper load rating and posting. Specifically, the legal loads used for load rating and posting and the posting requirements do not satisfy those given in the AASHTO *MBE, 2nd Edition* (AASHTO, 2011). The purpose of this study was to summarize and compare load rating and posting procedures used in other states and to provide recommendations and information necessary to modify the load rating and posting procedures in INDOT's *Bridge Inspection Manual*, Part 3: Load Rating in order to satisfy 23 CR 650.313.

2. STATE LOAD RATING AND POSTING FINDINGS

2.1 Introduction

In order to understand how load rating and posting is performed in other states, department of transportation (DOT) manuals were examined, and questionnaires were sent to states (see "Reference List of Questionnaire Communications and DOT Manuals Consulted" following "References"). The information collected on load rating and posting included, but was not limited to: AASHTO manual used for load rating and posting, application of ASR, application of LFR, application of LRFR, legal vehicles, and posting signage. Once this information was collected, additional states of interest were surveyed.

Detailed information on load rating and posting from DOT manuals and corresponding surveys were gathered from 42 states, with partial information from 5 additional states. A table of this information can be found in Appendix A (Figure A.1). The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) and older AASHTO bridge evaluation manuals (AASHTO 1994, 2003, 2008) were also reviewed.

2.2 AASHTO Manual Used for Load Rating and Posting

Part 3: Load Rating, Chapter 2 of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently refers to the AASHTO *The Manual for Bridge Evaluation, First Edition* (*MBE*) (AASHTO, 2008). In gathering information on what manual states use for load rating and posting, it was found that several different AASHTO bridge evaluation manuals are used. The AASHTO *MBE*, as well as the current AASHTO *MBE, 2nd Edition* (AASHTO, 2011), and older AASHTO bridge evaluation manuals (AASHTO, 1994, 2003) are referenced by various states. Many states specify the "latest" or "current" edition of the AASHTO *The Manual for Bridge Evaluation*. For these states, it was assumed that the AASHTO *MBE, 2nd Edition* was used.

As illustrated in Figure 2.1, the most frequently used manual is the AASHTO *MBE, 2nd Edition* (AASHTO, 2011). Several states that are using older AASHTO bridge evaluation manuals (AASHTO 1994, 2003, 2008) are evaluating bridges based only on the ASR or LFR methods found in these manuals.

2.3 Application of Allowable Stress Rating

Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently does not specify any use of ASR. The survey results indicate widespread use of ASR by the states for various reasons. The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) provides guidance

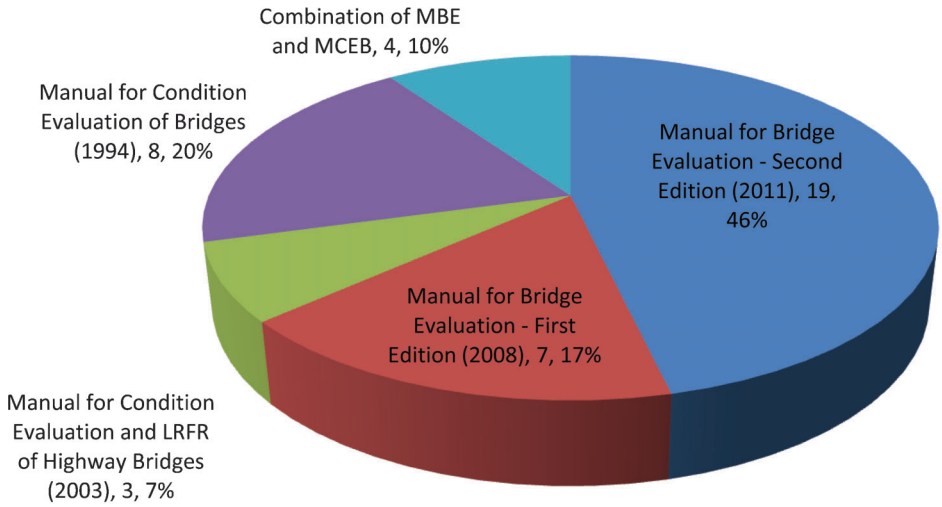

Figure 2.1 AASHTO manual used for load rating and posting.

on the use of ASR in Section 6, Part B, but does not specify any preferred uses of ASR.

As shown in Figure 2.2, the majority of states that responded to the survey are using ASR only for timber, masonry, truss, or other miscellaneous elements. Several states are not using ASR at all, while a considerable number of states accept the ASR method. The states that specify that ASR is acceptable are generally only using ASR for bridges that were designed by allowable stress design (ASD). Overall, it appears that states are beginning to discontinue the use of the ASR method.

2.4 Application of Load Factor Rating

Chapter 7 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that LFR can be used for bridges designed by ASD or load factor design (LFD). The survey results indicate that states prefer to use LFR for different reasons. The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) provides guidance on the use of LFR in Section 6, Part B, but does not specify any preferred uses of LFR.

As shown in Figure 2.3, the majority of states that responded to the survey specify that LFR is acceptable. Many states also use LFR as the preferred method for load rating and posting. The states that specify that LFR is acceptable are generally using LFR for bridges that were designed by either ASD or LFD.

2.5 Application of Load and Resistance Factor Rating

Chapter 7 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that LRFR is to be used for bridges designed by load and resistance factor design (LRFD) using the HL-93 design vehicle. Chapter 7 also specifies that LRFR can be used for bridges designed by ASD or LFD. The survey results indicated wide acceptance of the LRFR method. The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) provides guidance on the use of LRFR in Section

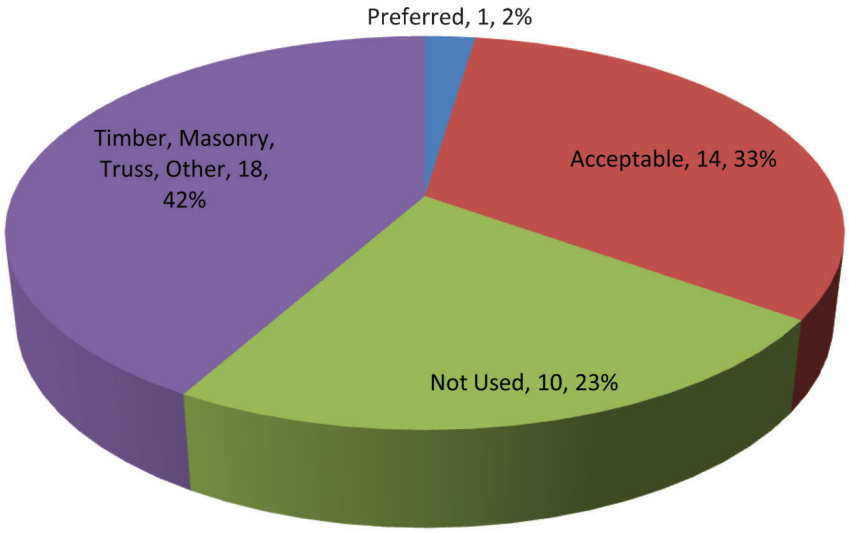

Figure 2.2 Application of allowable stress rating.

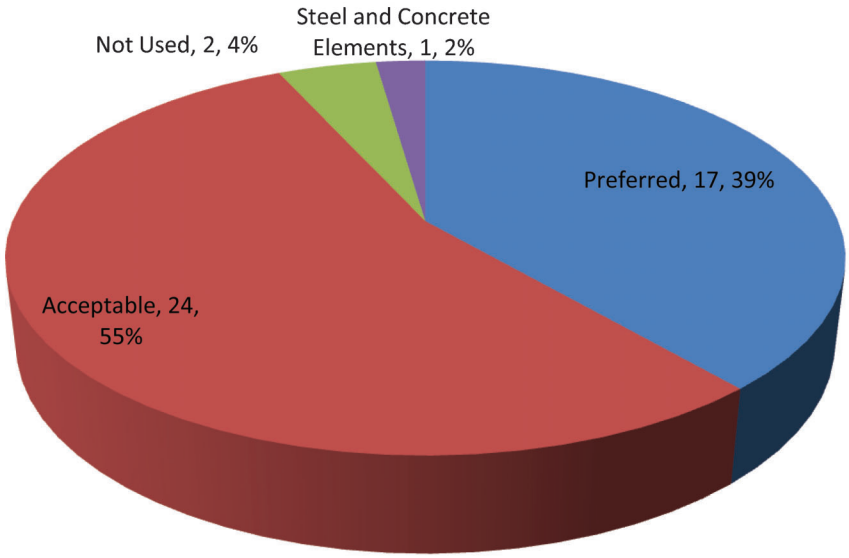

Figure 2.3 Application of load factor rating.

6, Part A, but does not specify any preferred uses of LRFR.

As illustrated in Figure 2.4, a large majority of states that responded to the survey specify that LRFR is acceptable. Several states also use LRFR as the preferred method for load rating and posting, and about an equal number of states do not use LRFR at all. The states that specify that LRFR is acceptable are generally using LRFR for bridges that were designed by LRFD. Moreover, some of the states that specify that LRFR is not used do specify that they plan to use LRFR in the future. Also, it was observed that some states that specify that LRFR is not used specify that only because they have not needed to post any bridges that were designed by the LRFD method; if a bridge designed by LRFD required load posting, the state indicated that it would use the LRFR method.

2.6 Preferred Method Used for Load Rating and Posting

Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently does not specify a preferred method for load rating and posting, although, it seems like the LFR method is preferred. The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) provides guidance on the use of all three load rating and posting methods, but does not specify a preferred method.

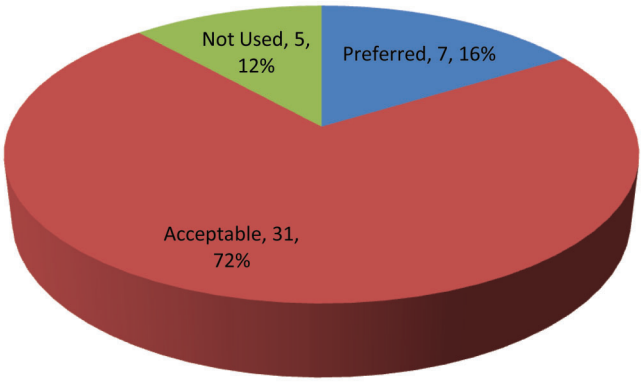

Figure 2.4 Application of load and resistance factor rating.

As illustrated in Figure 2.5, the majority of states that responded to the survey do not specify a preferred method for load rating and posting. The LFR method is the most preferred of the three methods, and the ASR method is the least preferred of the three methods. It was also observed that states seem to be moving towards use of the LRFR method as their preferred method. Several states specified that they plan to use the LRFR method in the future.

2.7 Legal Vehicles Used for Load Rating and Posting

Part 3: Load Rating, Chapter 7.1 of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that the legal vehicle used for load rating and posting is the H-20 vehicle (Figure 2.6). The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) specifies that the legal loads shall consist of the three AASHTO legal trucks (Figure 2.7) or the state legal loads and the four AASHTO specialized hauling vehicles (SHVs) (Figure 2.8).

As shown in Figure 2.9, the majority of states that responded to the survey use the AASHTO prescribed legal loads or similar state variations of these loads. Of these states, slightly more than half are considering the SHVs. Many states also use state specific legal loads. Some states may use only three or four legal loads, while others may use ten or more legal load configurations. Several states, like Indiana, are using previously specified design vehicles for the ASD and LFD methods, such as the H-20 or the HS-20 for legal loads. These states are grouped in the "other" category.

2.8 Survey of Selected States

Once all of the information on load rating and posting from the DOT manuals and questionnaires (see

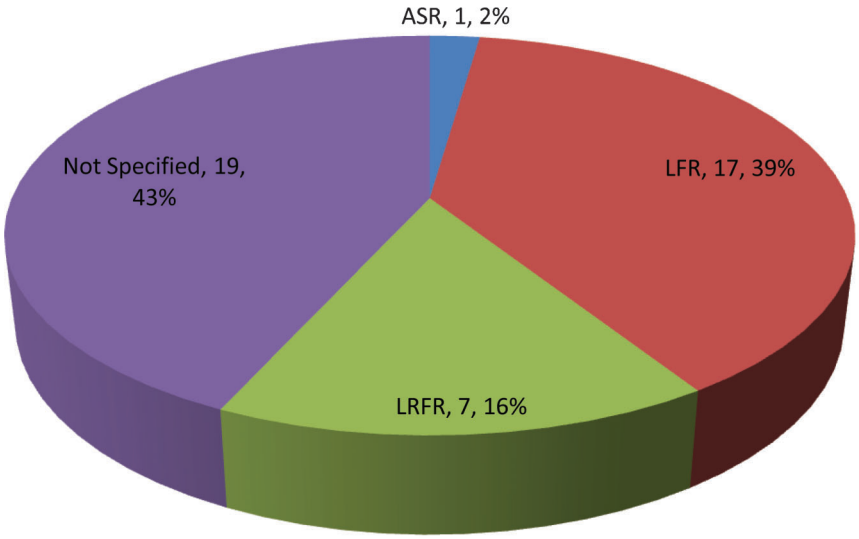

Figure 2.5 Preferred method used for load rating and posting.

"Reference List of Questionnaire Communications and DOT Manuals Consulted" following "References") was collected and examined, additional states of interest were surveyed. The topics of interest that still remained involved the use of the LRFR method, the use of the specialized hauling vehicles, and posting signage. The two states that were surveyed in order to try to answer these questions were Minnesota and Delaware. Copies of these surveys can be found in Appendix B.

With the LRFR method being the newest of the three methods used for load rating and posting, many states are hesitant to use this method instead of the ASR or LFR methods. States may not want to use the LRFR method for a few reasons including: existing resources for the ASR and LFR methods, unknown differences in rating factors determined by the LRFR method, and more conservative posting loads per Eq. 6A.8.3-1 under the LRFR method. Delaware specifies use of the LRFR method for all bridges. In surveying Delaware, it was discovered that new load ratings were performed on all bridges after the LRFR method was first implemented. Delaware found that the rating factors calculated by the LRFR method were comparable to the rating factors calculated by the ASR and LFR methods. In cases where posting is required by the LRFR method, but not by the ASR or LFR methods, Delaware often performs load testing on the bridge to achieve more accurate results.

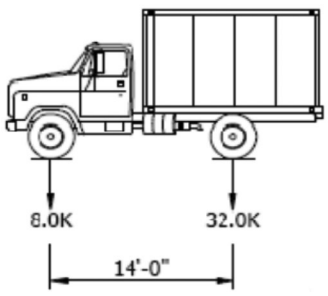

Figure 2.6 H-20 vehicle (INDOT, 2010).

The specialized hauling vehicles (Figure 2.8) were recently developed to model common, short wheelbase, multi-axle vehicles. These vehicles can produce extreme loading effects, and they were previously not considered in load rating and posting (AASHTO, 2011). From the information collected, it was observed that most states are still not considering the use of these vehicles in the load rating and posting process, even though they are required to use them according to the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), if these vehicles legally operate in their state. Minnesota was one of the states that specify the use of the specialized hauling vehicles in load rating and posting. In surveying Minnesota, it was found that much time and money was spent re-rating bridges when the specialized hauling vehicles were implemented. Minnesota did not re-rate all bridges, but they did re-rate bridges that had low previously calculated rating factors (near or below 1.0). The specialized hauling vehicles were found to cause many bridges that were not previously posted to be posted.

When bridges are required to be posted for restrictive loading, one of two signs is commonly used: R12-1 or R12-5 (Figure 2.10). The R12-1 sign gives a single gross tonnage value. This sign is commonly used when severe weight restrictions exist. The R12-5 sign gives three truck silhouettes, with their corresponding allowable gross tonnage value. In general, the top silhouette represents the AASHTO Type 3 legal truck, the middle silhouette represents the AASHTO Type 3S2 legal truck, and the bottom silhouette represents the AASHTO Type 3-3 legal truck. Both of these signs are specified in the Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices* (FHWA, 2009). After examining the DOT manuals and questionnaires (see "Reference List of Questionnaire Communications and DOT Manuals Consulted" following "References"), it was unknown how state legal

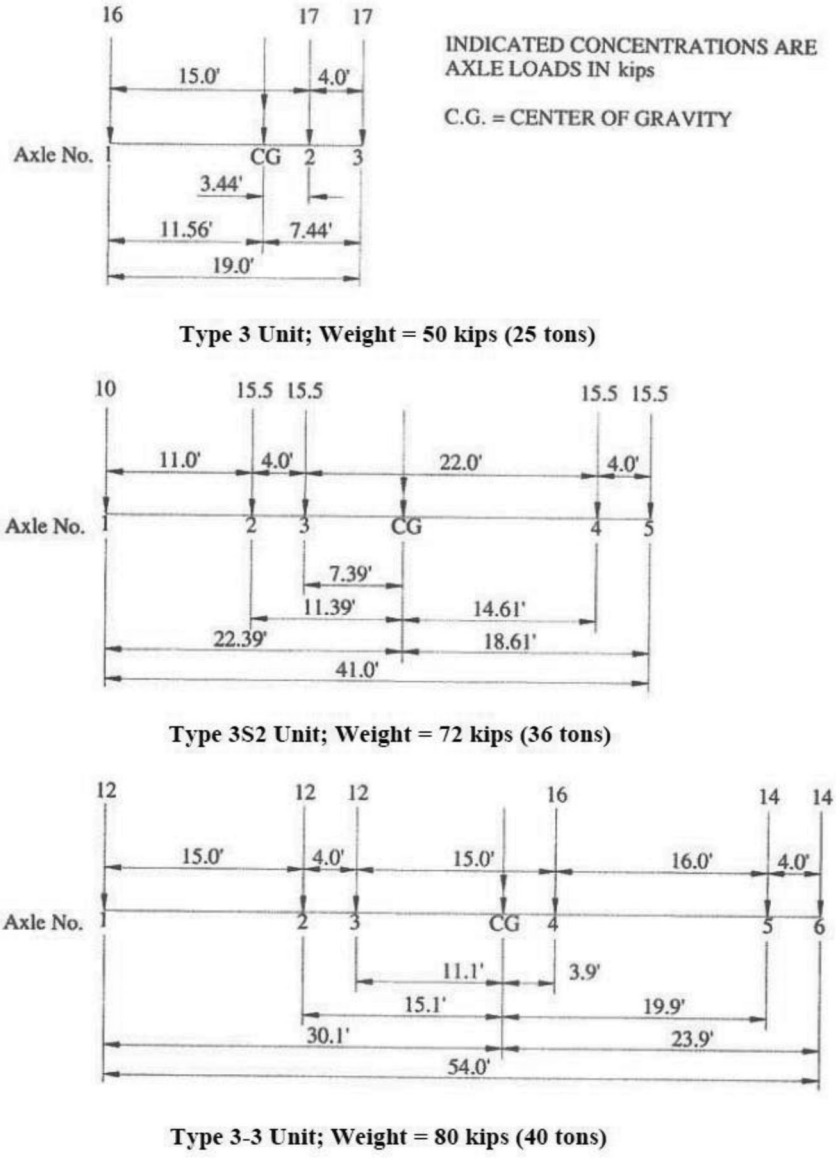

Figure 2.7 AASHTO legal trucks (AASHTO, 2011).

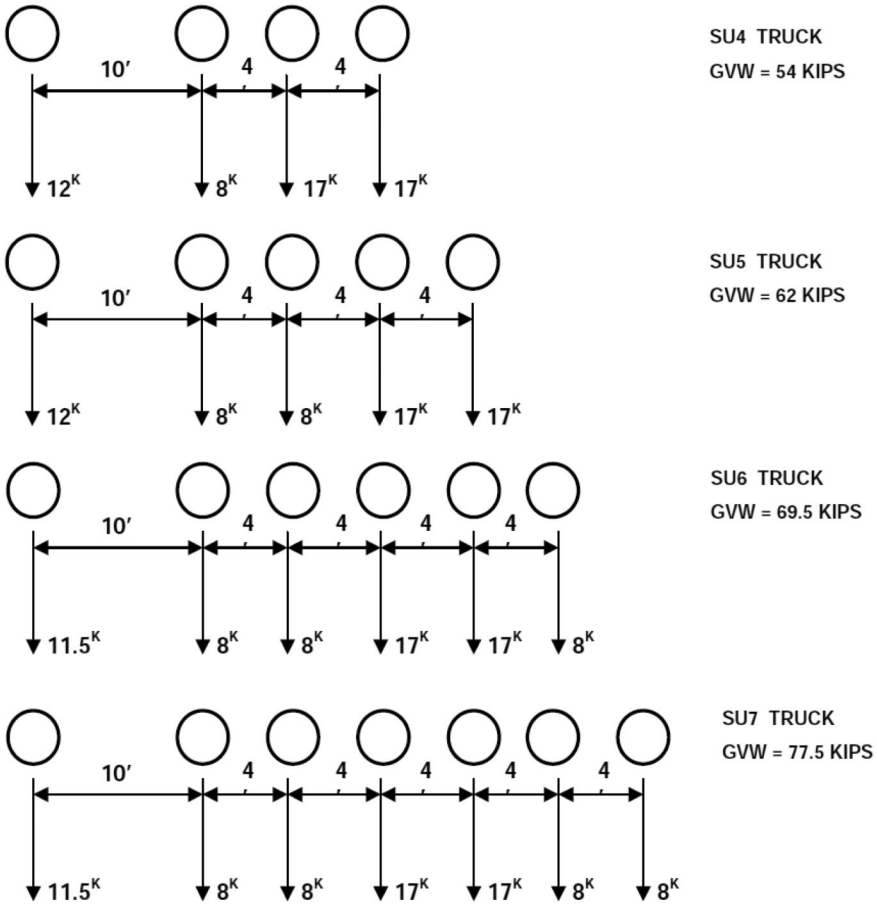

Figure 2.8 AASHTO specialized hauling vehicles (AASHTO, 2011).

loads and specialized hauling vehicles were posted for most states.

Delaware specifies that they use six state legal loads, and that they prefer to use the R12-5 sign when bridges are required to be posted. After surveying Delaware, it was discovered that Delaware uses a variation of the R12-5 sign. Only the legal vehicles that require posting are shown on the silhouette sign that Delaware uses. Therefore, anywhere from one to six vehicles could be shown on their sign.

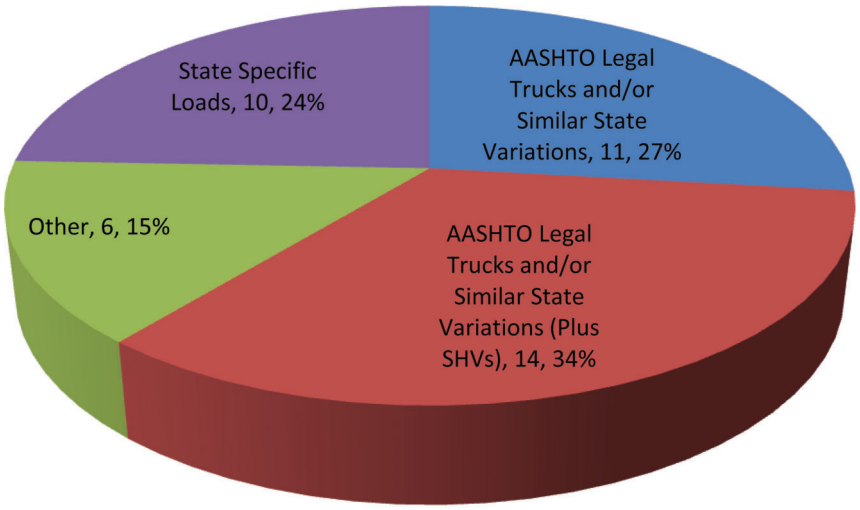

Figure 2.9 Legal vehicles used for load rating and posting.

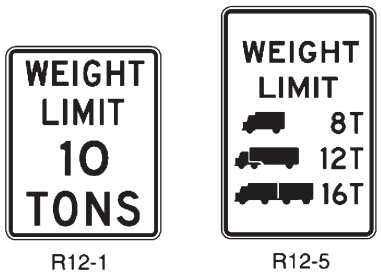

Figure 2.10 Common restrictive weight limit signs (FHWA, 2009).

Minnesota specifies that the specialized hauling vehicles are used in load rating and posting, and that they also prefer to use the R12-5 sign when bridges are required to be posted. In surveying Minnesota, it was found that the four specialized hauling vehicles, along with the Minnesota Type 3 legal truck, are included in the top silhouette on the R12-5 sign. The truck of these five vehicles which results in the lowest allowable gross tonnage is represented by the top silhouette. It is unknown if this same process is used for the posting of specialized hauling vehicles in other states. An example of how the loads on each sign are determined can be found in Appendix C.

3. SAMPLE BRIDGE LOAD RATING FINDINGS

3.1 Introduction

In order to better understand the load rating and posting procedures required by the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), and how the procedures specified in Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) compare, sample bridges were evaluated. Single and multi-span, steel and prestressed concrete, bridges were evaluated for posting using all three load rating and posting methodologies. Detailed calculations of the load rating and posting evaluation of these bridges can be found in Appendix D.

In particular, these bridges were evaluated to determine how INDOT's current practice for load rating and posting compared to the requirements of the AASHTO *MBE, 2nd Edition* (AASHTO, 2011). Specifically, Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) specifies that all load rating and posting evaluation is based on the H-20 vehicle. The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) specifies that posting shall be based on the three AASHTO legal trucks or the state legal loads and the four AASHTO specialized hauling vehicles. The sample bridges were rated using the H-20 vehicle, as well as the three AASHTO legal trucks and the four AASHTO specialized hauling vehicles, to determine if the H-20 vehicle covered all of the AASHTO loads.

3.2 Findings

Four different bridges were analyzed for posting using all three load rating and posting methodologies. Analyzing these bridges was valuable in learning the load rating and posting process required by both the AASHTO *MBE, 2nd Edition* (AASHTO, 2011) and Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010). Although analyzing these bridges helped to understand the load rating and posting process, they did not provide clear conclusions on relationships between INDOT's current practice and the AASHTO *MBE, 2nd Edition* (AASHTO, 2011).

The sample bridges were rated using the H-20 vehicle, which INDOT uses for posting, as well as the three AASHTO legal trucks and the four AASHTO specialized hauling vehicles, which AASHTO specifies to be used for posting. In some cases, the H-20 vehicle did cover all of the AASHTO loads, if the R12-1 sign were used, meaning that the H-20 vehicle resulted in the lowest safe posting load. There were other cases where the H-20 vehicle did not cover all of the AASHTO loads. This generally occurred under the LRFR method, because the LRFR method specifies a more conservative equation in determining the posting loads. INDOT specifies that the posting load shall be the rating factor multiplied by the gross vehicle weight, for all three methods. Because the H-20 vehicle did not cover all of the AASHTO loads in all cases, even on the few bridges that were evaluated, the H-20 vehicle should not be used for load rating and posting evaluation.

4. LOAD RATING AND POSTING RECOMMENDATIONS

4.1 Introduction

Part 3: Load Rating of INDOT's current *Bridge Inspection Manual* (INDOT, 2010) has limited guidance and requirements on load rating and posting. Chapter 7: "Vehicles" and Chapter 10: "Posting" cover load rating and posting methods, legal loads, and posting requirements for Indiana bridges, but lack necessary detail for load rating and posting. In comparison with other state DOT manuals and AASHTO manuals, the INDOT *Bridge Inspection Manual* (Part 3: Load Rating) needs to be modified to include more load rating and posting guidance in order to satisfy 23 CFR 650.313.

While many other state DOT manuals provide limited information on load rating and posting, several state DOT manuals provide complete guidance on load rating and posting procedures. Information and language from these state DOT manuals can be applied to the INDOT *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010) in order to eliminate current deficiencies.

The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) provides the most recent bridge load rating and posting guidelines. There seems to be some confusion on whether or not the AASHTO *MBE, 2nd Edition* is currently being used by INDOT. Moreover, the requirements in Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) do not clearly identify the governing requirements. Hence, Part 3:

Load Rating of INDOT's *Bridge Inspection Manual* should be modified to include language that satisfies the requirements given in the AASHTO *MBE, 2nd Edition*.

4.2 General

Chapter 7 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently provides some general guidelines for load rating and posting. In this chapter, each of the three methods (ASR, LFR, LRFR) along with the vehicles used for load rating and posting are introduced. This information could be separated and discussed in more detail in order to make the load rating and posting process more clear.

Looking at several state DOT manuals that provide thorough load rating and posting requirements, a general overview of the load rating and posting process is given at the beginning of their manuals. This overview typically includes: governing manuals, reasons for load rating and posting, and load rating methods.

The current Chapter 1 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) gives an introduction to load rating and posting. New language, as well as current language from Chapter 7, could be added to Chapter 1 in order to give a clear and complete introduction to the load rating and posting process. Appendix E.1 illustrates how recommended general language on load rating and posting could be implemented into INDOT's *Bridge Inspection Manual* (Part 3: Load Rating).

4.3 Allowable Stress Rating

Chapter 7 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently does not specify that the ASR method is used, although it is not specifically stated that the ASR method is not used.

Looking at several state DOT manuals that provide thorough load rating and posting requirements, the ASR method is often discussed in its own section. This section typically includes guidance on when and how to use the ASR method.

Appendix E.2 shows how recommended language on the ASR method could be implemented into INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010).

4.4 Load Factor Rating

Chapter 7 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that LFR can be used for bridges designed by ASD or LFD. Although it is specified that the LFR method is being used, there is little guidance on how to use the LFR method.

Looking at several state DOT manuals that provide thorough load rating and posting requirements, the LFR method is often discussed in its own section. This section typically includes guidance on when and how to use the LFR method.

Appendix E.3 shows how recommended language on the LFR method could be implemented into INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010).

4.5 Load and Resistance Factor Rating

Chapter 7 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that LRFR is to be used for bridges designed by LRFD using the HL-93 design vehicle. Chapter 7 also specifies that LRFR can be used for bridges designed by ASD or LFD. Although it is specified that the LRFR method is being used, there is little guidance on how to use the LRFR method.

Looking at several state DOT manuals that provide thorough load rating and posting requirements, the LRFR method is often discussed in its own section. This section typically includes guidance on when and how to use the LRFR method.

Appendix E.4 illustrates how recommended language on the LRFR method could be implemented into INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010).

4.6 Rating Vehicles

Chapter 7.1 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that the vehicle used for both load rating and posting is the H-20 vehicle. As noted earlier, this vehicle does not encompass all of the AASHTO legal loads and should not be used. The manual does not reference the legal vehicles that are given in the AASHTO *MBE, 2nd Edition* (AASHTO, 2011).

Looking at several state DOT manuals that provide thorough load rating and posting requirements, the design vehicles are often discussed with each load rating and posting method, while the legal vehicles are often discussed in their own section. This section typically includes guidance on when to use each vehicle along with figures of each vehicle.

Appendix E.5 shows how the recommended language on the legal vehicles could be implemented into INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010).

4.7 Posting

Chapter 10 (Part 3: Load Rating) of INDOT's *Bridge Inspection Manual* (INDOT, 2010) currently specifies that when a bridge has an inventory level capacity less than 16.0 tons for the H-20 vehicle, it shall be posted. The manual states that the bridge shall be posted for the tonnage capacity using the R12-1 sign.

The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) states that a bridge shall be posted when the maximum legal load under state law exceeds the safe load capacity of a bridge. According to the AASHTO *MBE, 2nd Edition*, the loads to be used for posting considerations

should be any of the three typical AASHTO legal trucks or the state legal loads and any of the four AASHTO specialized hauling vehicles. No preference is given on posting signage.

Looking at several state DOT manuals that provide thorough load rating and posting requirements, the posting requirements typically follow those given in the AASHTO *MBE, 2nd Edition* (AASHTO, 2011). States typically state these requirements and discuss posting signage preferences.

Appendix E.6 shows how the recommended language on load posting could be implemented into INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010).

5. SUMMARY AND CONCLUSIONS

The goal of this study was to summarize and compare load rating and posting procedures used in other states and to provide recommendations and information necessary to modify the load rating and posting procedures in Part 3: Load Rating of INDOT's *Bridge Inspection Manual* (INDOT, 2010) order to satisfy 23 CR 650.313. Based on the load rating and posting information collected from other state DOT manuals and AASHTO bridge evaluation manuals, the following provisions are recommended for inclusion in Part 3: Load Rating of INDOT's *Bridge Inspection Manual*:

- The current AASHTO *MBE, 2nd Edition* (AASHTO, 2011) is recommended for adoption by INDOT, and that the use of this document be clearly stated.
- The AASHTO prescribed legal loads, or similar state variations of these loads, are recommended for use in load rating and posting.
- The load posting requirements prescribed by the AASHTO *MBE, 2nd Edition* are recommended for adoption.

Implementing these provisions is necessary in order for INDOT's *Bridge Inspection Manual* (Part 3: Load Rating) (INDOT, 2010) to satisfy 23 CFR 650.313. In addition, by adopting the proposed language, current load rating and posting deficiencies will be eliminated from INDOT's *Bridge Inspection Manual* (Part 3: Load Rating).

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APPENDIX A. STATE LOAD RATING AND POSTING INFORMATION

In order to understand how load rating and posting is performed in other states, department of transportation (DOT) manuals were examined, and questionnaires were sent to states (see "Reference List of Questionnaire Communications and DOT Manuals Consulted" following "References"). Detailed information on load rating and posting from DOT manuals and corresponding surveys were gathered from 42 states, with partial information from 5 additional states. This information can be found in Figure A.1. (NOTE: For references in the last column of Figure A.1, see "Reference List of Questionnaire Communications and DOT Manuals Consulted" on pp. 9–10.)

State	AASHTO Manual for Bridge Evaluation	Load Rating Software	Load Rating Methods			Load Rating Levels			Load Rating Vehicles			Load Posting Signage	Load Rating of Previously Posted Bridges	Reference
			Allowable Stress	Load Factor	Load and Resistance Factor	Inventory	Operating	Posting	Design	Legal	Permit			
Alabama	Manual for Condition Evaluation of Bridges (1994)	N/A	Acceptable	Most suitable	Acceptable	Loading which can be safely applied to an existing bridge for an indefinite period of time	Maximum permissible loading to which the structure may be subjected for a given vehicle	If maximum legal load exceeds the operating rating capacity	HL-93 (LRFR), HS-20 (ASR and LFR)	N/A	N/A	National MUTCD along with Alabama supplement	Substantially less than the 24 month standard; 12 months or less	2
Alaska	2nd Edition (2011)	In house	Not used	Preferred method	Consultant and new bridges	Load level which can safely utilize an existing structure for an indefinite period of time	Absolute maximum permissible load level to which the structure may be subjected	If legal load effects exceed inventory level	HL-93 (LRFR), HS-20 (LFR)	AASHTO Legal Trucks, 1, 2, 3, 4 Axles	As required	National MUTCD along with Alaska supplement	As required	3
Arizona	N/A	N/A	Not used	Preferred method	Not used	Load level which can safely utilize an existing structure for an indefinite period of time	Absolute maximum permissible load level to which the structure may be subjected	N/A	HS-20	Arizona Legal Trucks	N/A	National MUTCD along with Arizona supplement	N/A	4
Arkansas	2nd Edition (2011)	Bentley LARS, PENNDOT BAR, others	Timber and masonry bridges	Majority of bridges (Prestressed and reinforced concrete, steel bridges)	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Load level which can safely utilize an existing structure for an indefinite period of time	Absolute maximum permissible load level to which the structure may be subjected	If bridge is not capable of safely supporting legal load vehicles	HL-93 (LRFR), HS-20 (ASR and LFR)	Arkansas Legal Trucks	N/A	National MUTCD; R12-5 used	N/A	5, 6
California	2nd Edition (2011)	AASHTO-Ware Virtus	Timber bridges	Acceptable	Preferred method	Load level which can safely utilize an existing structure for an indefinite period of time	Absolute maximum permissible load level to which the structure may be subjected	If maximum legal load exceeds the operating rating capacity	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal Trucks	5 Trucks for LFD, 7 Trucks for LRFD	California MUTCD	As required	7
Colorado	"Current Edition"	AASHTO-Ware Virtus	Not used	Bridges designed by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (LFR)	AASHTO Legal Trucks	As required	National MUTCD along with Colorado supplement	N/A	8
Connecticut	Manual for Condition Evaluation of Bridges (1994)	PENNDOT BAR7, PS3, and BOX5 (and several others)	Acceptable	Preferred method	Not used	Design level of stress, results in a live load that can safely use the bridge for an indefinite time	Maximum permissible live load that should never be exceeded on the bridge	Inventory capacity < 30 tons (HS20), < 35 tons (3S2), < 18 tons (H20), 4 axle > operating	HS-20	H-20, Type 3S2, 4-Axle Construction	As required	National MUTCD	More frequent than two year interval when known deficiences or questionable conditions exist	9
Delaware	1st Edition (2008)	BRASS-Girder preferred	Not used	Not used	Preferred method	Capacity rating that will result in a live load that can safely utilize the structure for an indefinite time	Capacity rating that will result in the absolute maximum live load	If legal load effects exceed operating level	HL-93 and HS-20	Delaware Legal Trucks (State SHV)	As required	Delaware MUTCD; R12-5 preferred	N/A	10, 11
Florida	"Current Edition"	AASHTO-Ware Virtus	Not used	Existing structures not designed by LRFD	Preferred method; Bridges designed by LRFD after 01/01/2005	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (LFR)	Florida Legal Trucks (State SHV)	FL120 (bridges designed after 01/01/2005)	National MUTCD	N/A	12, 13

Figure A.1 State load rating and posting information. (For references in last column, see "Reference List of Questionnaire Communications and DOT Manuals Consulted" on pp. 9–10.)

State	AASHTO Manual for Bridge Evaluation	Load Rating Software	Load Rating Methods			Load Rating Levels			Load Rating Vehicles			Load Posting Signage	Load Rating of Previously Posted Bridges	Reference
			Allowable Stress	Load Factor	Load and Resistance Factor	Inventory	Operating	Posting	Design	Legal	Permit			
Georgia	1st Editon (2008)	In house	Timber and other misc. structures	Preferred method	Bridges designed by LRFD	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	Georgia Legal Trucks	As requried	National MUTCD; modified R12-5 (6 silhouette)	As required	14
Hawaii	Manual for Condition Evaluation and LRFR (2003) and 1st Edition (2008)	BRASS	N/A	N/A	All new or rehabilitated structures designed using LRFD	N/A	N/A	If legal load effects exceed operating level	HL-93	AASHTO Legal Trucks and SHV	Hawaii Permit Trucks	National MUTCD	N/A	15
Idaho	1st Edition (2008)	N/A	Acceptable	Acceptable	Acceptable	Safe load level to which the structure can be subjected for an indefinite period of time	Absolute maximum permissible load level to which the structure may be subjected	If maximum legal load produces stresses in excess of the operating level stresses	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal Trucks	As required	National MUTCD along with Idaho supplement; R12-5 with single tonnage	Substantially less than the 24 month standard	16
Illinois	1st Edition (2008)	N/A	Acceptable	Acceptable	Acceptable	Capacity rating that will result in a live load that can safely utilize the structure for an indefinite time	Capacity rating that will result in the absolute maximum live load	If a structure can not carry the legal load	HL-93 (LRFR), HS-20 (ASR and LFR)	625 ILCS 5/15-317	N/A	National MUTCD along with Illinois supplement	N/A	17
Indiana	1st Edition (2008)	AASHTO-Ware Virtis	Bridges designed under this method	Bridges designed under this method	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	Inventory rating less than HS-16	HL-93 (LRFR), HS-20 (ASR and LFR)	Inidana Code Article 20	As required	Indiana MUTCD; only R12-1 may be used	N/A	1
Iowa	Manual for Condition Evaluation of Bridges (1994)	Bentley LARS and Culvert software	Acceptable for old bridges	Bridges desinged by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Load level which can safely utilize the bridge for an indefinite period of time	Absolute maximum permissible load level for the bridge	If legal load stresses exceed operating level stresses	HL-93 (LRFR), HS-20 (ASR and LFR)	Iowa Legal Trucks	N/A	National MUTCD along with Iowa supplement	N/A	18
Kansas	Manual for Condtion Evaluation of Bridges (1994)	AASHTO-Ware Virtis and BRASS-Girder	Majority of bridges	Most bridges; must include fatigue, crack control, serviceablity	Not used or recommended at this time	N/A	N/A	If legal load effects exceed operating level	HS-20	AASHTO and Kansas Legal Trucks	T130 and T170 on state highways	National MUTCD; R12-5 recommended	N/A	19
Kentucky	2nd Edition (2011) and Manual for Cond. Eval. of Bridges (1994)	Bentley LARS	Bridges designed under this method or unknown design	Bridges designed under this method	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity which can safely utilize the bridge for an indefinite period	Maximum permissible load considering current conditions	If a structure cannot carry the legal load	KY HL-93	Kentucky Legal Trucks	As required	National MUTCD; with KY trucks and coal hauling specifications	Inspected anually, load rated as requried	20
Louisiana	2nd Edition (2011)	AASHTO-Ware Virtus	Timber	Not used	Bridges designed by LRFD Specifications and all new ratings	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (ASR)	AASHTO and LA Legal Trucks, SHV	Annual permits and single-trip permits	National MUTCD; R12-1 and R12-5	6-12 months	21, 22
Maine	N/A	N/A	Acceptable	Acceptable	Preferred method	Load level which can safely utilize the bridge for an indefinite period of time	Absolute maximum permissible load level for the bridge	If bridge cannot support legally loaded vehicles	HL-93 (LRFR), HS-20 (ASR and LFR)	Maine Legal Trucks (State SHV)	N/A	National MUTCD	N/A	23
Maryland	1st Edition (2008)	Bentley LARS	Timber and masonry bridges	Existing bridges undergoing major rehab not desinged by LRFD	Bridges designed by LRFD	Load level which can safely utilize the bridge for an indefinite period of time	Absolute maximum permissible load level for the bridge	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	H-15, T-3, T-4, HS-20, Type 3S2	Maryland Permit Vehicles	Maryland MUTCD; Sign shows gross single and combination	As required	24

Figure A.1 Continued.

State	AASHTO Manual for Bridge Evaluation	Load Rating Software	Load Rating Methods			Load Rating Levels			Load Rating Vehicles			Load Posting Signage	Load Rating of Previously Posted Bridges	Reference
			Allowable Stress	Load Factor	Load and Resistance Factor	Inventory	Operating	Posting	Design	Legal	Permit			
Massachusetts	"Current Edition" (LRFR) & Man. for Cond. Eval. of Bridges (ASR, LRF)	AASHTO-Ware Virtus	Bridges designed by ASD	Bridges designed by LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If legal load effects exceed inventory level	HL-93 (LRFR), HS-20 (ASR and LFR)	H-20, Type 3, Type 3S2	As required	National MUTCD; R12-5 preferred	As required	25, 26
Michigan	2nd Edition (2011)	AASHTO-Ware Virtus (and several others)	Timber and masonry bridges	Bridges designed by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions; in terms of HS	Maximum permissible load capacity, considering current conditions	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	Michigan Legal Trucks (State SHV)	As required	Michigan MUTCD; R12-5 most common	N/A	27
Minnesota	1st Edition (2008)	N/A	Not used	Only method used for load posting	All new and major rehab bridges; LRFR used for load rating	Capacity rating that will result in a live load that can safely utilize the structure for an indefinite time	Capacity rating that will result in the absolute maximum live load	If legal load effects exceed operating level	HL-93 (LRFR), HS-20 (LFR)	AASHTO and Minnesota Legal Trucks, SHV	As required	Minnesota MUTCD; R12-5 most common	N/A	28, 29
Mississippi	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	National MUTCD	N/A	N/A
Missouri	2nd Edition (2011)	AASHTO-Ware Virtus and Bentley LARS	Few bridges	Majority of bridges; Posting typically based on this method	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	68% stress level for AS, 86% of operating rating for LF	HL-93 (LRFR), HS-20 (ASR and LFR)	H-20, 3S3, MO5	N/A	Missouri MUTCD	N/A	30, 31
Montana	N/A	N/A	Timber bridges	Majority of bridges	Majority of bridges	The load level that can be safely resisted by a structure for an indefinite period of time	The maximum permissible load level to which the structure may be subjected	N/A	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal Trucks	N/A	National MUTCD; use both R12-1 and R12-5, counties prefer R12-1	N/A	32, 33
Nebraska	2nd Edition (2011)	BRASS-LRFR	Timber and masonry bridges	Steel and concrete elements	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If load effects exceed operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	Nebraska Legal Trucks	As required	National MUTCD along with Nebraska supplement; R12-5 highly recommended	N/A	34
Nevada	Manual for Condition Evaluation and LRFR of Highway Bridges (2003)	BRASS-Girder	Not used	Method used	Not used	Load level that can safely use an existing structure for an indefinite period of time	Maximum permissible load level to which the structure may be subjected	If legal load effects exceed operating level	HS-20	N/A	Caltrans P5, P7, P9, P11, P13	National MUTCD along with Nevada supplement	Inspected at least once every 12 months	35
New Hampshire	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	HS-20	New Hampshire State Legal Loads	N/A	National MUTCD	Inspected every 6 months	36
New Jersey	2nd Edition (2011)	Bentley LARS	Bridges designed by ASD	Bridges desingeed by LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If load effects exceed operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO and New Jersey Legal Trucks, SHV	Superload	National MUTCD	N/A	37, 38
New Mexico	"Current Edition"	AASHTO-Ware Virtis	Timber bridges and decks	All bridges (Prestressed concrete, reinforced concrete, and steel bridges)	Not yet using, but plan to in the future	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	Operating rating less than HS-17 require rating with legal trucks	HS-20	AASHTO and New Mexico Legal Trucks	N/A	National MUTCD; use both R12-1 and R12-5, locally owned prefer R12-1	N/A	39, 40

Figure A.1 Continued.

State	AASHTO Manual for Bridge Evaluation	Load Rating Software	Load Rating Methods			Load Rating Levels			Load Rating Vehicles			Load Posting Signage	Load Rating of Previously Posted Bridges	Reference
			Allowable Stress	Load Factor	Load and Resistance Factor	Inventory	Operating	Posting	Design	Legal	Permit			
New York	N/A	AASHTO-Ware Virtus or BLRS	Acceptable	Acceptable	Acceptable	N/A	N/A	N/A	HL-93 (LRFR), HS-20 (ASR and LFR)	N/A	N/A	National MUTCD along with New York supplement	N/A	41
North Carolina	Manual for Condition Evaluation of Bridges (1994)	N/A	N/A	N/A	N/A	Load that can safely utilize the bridge for an indefinite period of time	Maximum permissible live load that can be placed on the bridge	If structure can not carry legal loads at operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	N/A	N/A	National MUTCD along with NC supplement	N/A	42
North Dakota	2nd Edition (2011)	AASHTO-Ware Virtus	Timber and truss structures	Preferred method (prestressed and steel)	Bridges designed by LRFD Specifications using HL-93	Load level that can safely use an existing structure for an indefinite periods of time	Max Live load Capacity of the structure	Post at any level up to the operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal Trucks	As required	National MUTCD along with ND supplement, R12-1	N/A	43, 44
Ohio	2nd Edition (2011) and Manual for Cond. Eval. and LRFR of Highway Bridges	AASHTO BARS preferred (many others used)	Not used	Preferred method	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Capacity rating that will result in a live load that can safely utilize the structure for an indefinite time	Capacity rating that will result in the absolute maximum live load	If a structure can not carry the legal load	HL-93 (LRFR), HS-20 (LFR)	Ohio Legal Loads (State SHV)	As required	Ohio MUTCD; R12-H5 (4 Ohio Legal Truck Silhouette) and R12-2	12 month minimum	45, 46
Oklahoma	2nd Edition (2011)	BAR7, BRASS, Virtus	Timber and truss structures	Preferred method	Bridges designed by LRFD Specifications using HL-93	Design level rating	Max permissible live load	Oper Rating < 36 tons HS for on system, Oper Rating < 23 tons H for off system	HL-93 (LRFR), HS-20 (ASR and LFR)	HS-20 for on system, H-20 for off system, 3-3	OL1 special	National MUTCD along with Oklahoma supplement; R12-5 shown	As required	47
Oregon	2nd Edition (2011)	BRASS-Girder (and others)	Bridges designed by ASD or LFD	Bridges designed by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If a structure can not carry the any of the loads	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO and Oregon Legal Trucks, SHV	Oregon cont. trip permit and single trip permit trucks	National MUTCD along with Oregon supplement	N/A	48
Pennsylvania	Manual for Condition Evaluation of Bridges (1994)	BAR7, PS3, BOX5	Trusses	Majority of bridges	Bridges designed by LRFD Specifications using HL-93	Load that can safely utilize the bridge for an indefinite period of time	Maximum permissible live load that can be placed on the bridge	If the maximum legal load configurations exceed the load allowed at Operating Level	HL-93 (LRFR), HS-20 (ASR and LFR)	PA Legal Loads (ML80 and TK527)	As required; PA P82 permit vehicle	National MUTCD along with Pennsylvania supplement	12 month minimum	49, 50
Rhode Island	Existing Bridge Evaluation and Rehabilitation section is under development	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	National MUTCD	N/A	N/A
South Carolina	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	National MUTCD along with SC supplement	N/A	N/A
South Dakota	2nd Edition (2011)	AASHTO-Ware Bridge Rating (Virtus)	Timber and truss structures	Bridges designed by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Load that can safely utilize the bridge for an indefinite period of time	Maximum permissible live load that can be placed on the bridge	If structure can not carry legal loads at operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	South Dakota Legal Trucks (Similar to AASHTO)	As required	National MUTCD	N/A	51
Tennessee	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	National MUTCD along with Tennessee supplement	N/A	N/A
Texas	Manual for Condition Evaluation of Bridges (1994)	Several used	Timber structures	Majority of bridges	Not used	Load that can safely utilize the bridge for an indefinite period of time	Maximum permissible live load that can be placed on the bridge	Expressed in terms of an equivalent HS-truck (RF< HS-20 evaluation for posting)	HS-20	Trucks that comply to current Texas size and weight laws	As required	Texas MUTCD; R12-2, R12-4, R12-8	N/A	52

Figure A.1 Continued.

State	AASHTO Manual for Bridge Evaluation	Load Rating Software	Load Rating Methods			Load Rating Levels			Load Rating Vehicles			Load Posting Signage	Load Rating of Previously Posted Bridges	Reference
			Allowable Stress	Load Factor	Load and Resistance Factor	Inventory	Operating	Posting	Design	Legal	Permit			
Utah	2nd Edition (2011)	AASHTO-Ware Virtus (and several others)	Only on timber structures	Bridges designed by ASD or LFD and truss structures	All bridges (except timber and truss structures)	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If structure can not carry legal loads	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal Trucks	Utah permit trucks and as required	National MUTCD along with Utah supplement	As required	53
Vermont	Manual for Condition Evaluation and LRFR of Highway Bridges (2003)	Various programs	Historic metal, timber truss, and historic arch bridges designed using ASD	All new or rehabilitated structures designed using LFD	All new or rehabilitated structures designed using LRFD	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If structure can not carry legal loads	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal Trucks	As requried	National MUTCD	N/A	54
Virginia	"Latest Edition"	AASHTO-Ware Virtus (and several others)	Not used	Acceptable	Acceptable	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If structure can not carry legal loads at operating level	HL-93 (LRFR), HS-20 (LFR)	AASHTO SHV and Virginia legal trucks	Virginia permit loads	National MUTCD along with Virginia supplement	As required	55
Washington	"Latest Edition"	BRIDG	Only on timber structures	Bridges designed by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If structure can not carry legal loads at operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	AASHTO Legal and WSDOT overload, SHV	As required	National MUTCD along with Washington supplement	N/A	56, 57
West Virginia	Manual for Condition Evaluation of Bridges (1994)	N/A	N/A	Method used for new bridges	N/A	N/A	N/A	N/A	N/A	N/A	N/A	National MUTCD along with WV supplement	N/A	58
Wisconsin	Manual for Condtion Evaluation and LRFR of Highway Bridges (2003)	N/A	Not used	Bridges designed by ASD or LFD	Bridges designed by LRFD Specifications using HL-93 after 10/01/2010	Design level capacity, considering current conditions	Maximum permissible load capacity, considering current conditions	If structure can not carry legal loads or Wis-SPV at operating level	HL-93 (LRFR), HS-20 (LFR)	AASHTO Legal Trucks and SHV, Wis-SPV	As required	National MUTCD along with Wisconsin supplement; R12-1	More frequent than two year interval required by NBIS	59
Wyoming	2nd Edition (2011)	BRASS-Girder	All trusses and timber bridges	All other bridge types	All bridges designed since 2007 rated using both LFR and LRFR	The weight of a given vehicle that can safely cross the structure on a daily basis	The maximum weight of a given vehicle that can safely cross the structure on an occasional basis	If a structure can not carry the legal loads at operating level	HL-93 (LRFR), HS-20 (ASR and LFR)	Wyoming Legal Trucks and SHV	As required	National MUTCD along with Wyoming supplement; R12-5 recommended	Inspected annually	60

Figure A.1 Continued.

APPENDIX B. SURVEYS OF SELECTED STATE

Once all of the information on load rating and posting from the DOT manuals and questionnaires was collected and examined, additional states of interest were surveyed. The two states that were surveyed were Delaware and Minnesota (see Figures B.1 and B.2).

Conference Call with Delaware DOT

1. In your response to our survey, you said that the LRFR method is used for all load and posting. To verify, the ASR and LFR methods are not used at all for rating or posting?

   Correct. LRFR is used for all bridges.

2. If the LRFR method is used for posting, how are the posting loads determined (i.e. RFxW or [W/0.7]x[RF-0.3])

   The posting loads are determined using the new LRFR equation (much more conservative).

3. If all of the load rating and posting is done by the LRFR method, how were these ratings implemented into the existing bridge ratings? Were new load ratings performed on all bridges? Or were the load ratings just done by LRFR when updated ratings were required?

   It seemed like new ratings were performed on all bridges. Ping said that at first the rating factors computed by LRFR were quite different from those computed by ASR or LFR, but after updates by AASHTO, the rating factors from each method are found to be comparable. Ping said that when it is found that posting is required by LRFR, but not by ASR or LFR, that Delaware often does load testing to achieve more accurate results.

4. Are the notional rating load and standard hauling vehicles considered in load rating and posting? If so, how were they implemented into the existing bridge load rating? The S437 – DE 4 Axle Single Unit vehicle is similar to the SHVs; does this cover the SHVs?

   Delaware does not use the standard hauling vehicles. They are not included in the Delaware legal loads.

5. Delaware states in the survey that they prefer the R12-5 silhouette sign. With 8 legal loads, how are these loads represented on the R12-5 sign with only 3 silhouettes?

   Delaware is only using 6 legal trucks now. From what we could tell, Ping said that Delaware uses silhouette signage, but only those legal vehicles which require posting are included on the silhouette sign (i.e. anywhere from 1 to 6 legal trucks could be represented on this sign). This sign is not necessarily the same for all posted bridges. Ping said that the S335, S437, and T435 vehicles typically control.

6. Additional information

   State performs all load ratings for state and county bridges.

Figure B.1 Delaware survey.

Conference Call with Minnesota DOT

1. In your response to our survey, you said that the LRFR method is used for load rating all new and major rehab bridges, but the LFR method is the only method used for posting. Is this due to the different load posting equations given by the MBE? Do you know if this is common in other states?

   If the bridge is designed by ASD or LFD, the bridge is rated using LFR. If the bridge is designed by LRFD, the bridge is rated by LRFR. The reason that they said the LFR method is the only method used for posting is that all of the new bridges which were designed by LRFD have sufficient capacity and do not require posting. If posting is necessary for bridges designed by LRFD, it would be done by LRFR.

2. If the LRFR method is only used for load rating, what are these ratings used for? Does Minnesota plan to use LRFR for load posting in the future?

   See question 1 above.

3. Are the notional rating load and standard hauling vehicles considered in load rating and posting? Do you know if this is common in other states?

   The notional rating load is not used in load rating and posting because it is not a posting load. The standard hauling vehicles are considered. Yihong thought that most states are similar to MN in that they do not consider the notional rating load.

4. At what load levels do you decide to post (if posting is done using LFR method, rating factors are calculated at both Inventory and Operating levels for legal loads)? Do you post when the legal load effects exceed the Operating level? Inventory level? Some other limit? A document on your website that discusses posting guidelines shows limiting rating factor values of 0.89 and 1.10. How were these values determined?

   The 1.10 threshold corresponds to a special requirement that MN has during the winter. During the winter, the allowable weight of the legal vehicles increases by 10%. MN only uses the inventory level for design loads; all of the rating factors for the legal loads are calculated at the operating level.

5. The same posting guidelines document said that when the R12-5 silhouette posting sign is used, the standard hauling vehicles are included in the top silhouette. We have typically seen that the top silhouette represents the Type 3 truck, the middle silhouette represents the Type 3S2 truck, and the bottom silhouette represents the Type 3-3 truck. We wanted to confirm that the standard hauling vehicles are indeed included in the top silhouette, because this is the only reference we have found that deals with the posting of standard hauling vehicles. Do you know if this is common practice?

   MN also uses the R12-1 sign when severe weight restrictions exist (when the bridge has a low capacity). MN also has a 45 ton permit sign that is sometimes used. Yihong was not sure how the standard hauling vehicles were posted in other states.

Figure B.2 Minnesota survey.

6. How were the standard hauling vehicles implemented into the existing load ratings? Were new load ratings performed on all bridges when the standard hauling vehicles were introduced? Or were the just included when new load ratings were performed?

   MN rerated a lot of bridges, and spent a lot of money, when the standard hauling vehicles were implemented. They did not re-rate all bridges, but they did re-rate bridges that had lower previously calculated rating factors (less than 1.0 or near 1.0). This causes many bridges that were previously not posted to be posted.

7. Additional information:

   State performs load ratings for state bridges. State provides an aid for country load ratings.

Figure B.2 Continued.

APPENDIX C. SAFE POSTING LOAD DETERMINATION

When bridges are required to be posted for restrictive loading, one of two signs is commonly used: R12-1 or R12-5. The R12-1 sign gives a single gross tonnage value. This sign is commonly used when severe weight restrictions exist. The R12-5 sign gives three truck silhouettes, with their corresponding allowable gross tonnage value.

The AASHTO *MBE, 2nd Edition* (AASHTO, 2011) states that a bridge shall be posted when the maximum legal load under state law exceeds the safe load capacity of a bridge. According to the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), the loads to be used for posting considerations should be any of the three typical AASHTO legal trucks or the state legal loads and any of the four AASHTO specialized hauling vehicles.

When the ASR or LFR methods are used for load rating and posting, the safe posting loads shall be determined according to AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Equation 6B.4.1-2:

$$Safe\ Load\ Capacity = RFxW$$

where RF = legal load rating factor and W = weight of rating vehicle. Posting is required when the RF for any legal vehicle is less than 1.0 at the Operating Level. Bridges may be posted at lower load levels (AASHTO, 2011).

When the LRFR method is used for load rating and posting, the safe posting loads shall be determined according to AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Equation 6A.8.3-1:

$$Safe\ Posting\ Load = \frac{W}{0.7}[(RF) - 0.3]$$

where RF = legal load rating factor and W = weight of rating vehicle. This equation is to be used when the RF of any legal vehicle is less than 1.0 and greater than 0.3. When the RF of each legal vehicle is greater than 1.0, the bridge need not be posted. When the RF of any legal vehicle is less than 0.3, that vehicle should not be allowed on the span (AASHTO, 2011).

An example showing how safe posting loads are determined is shown below. Table C.1 shows controlling rating factors for each of the legal loads to be used for posting consideration. The rating factors shown in this table were created for this example; they do not correspond to an actual bridge.

Consider the Type 3 legal vehicle. This vehicle has a gross weight of 25 tons. Looking at Table C.1, the controlling rating factor is 0.79 under the LRFR method. Using Equation 6A.8.3-1, the safe posting load is:

$$Safe\ Posting\ Load = \frac{W}{0.7}[(RF) - 0.3] = \frac{25\ tons}{0.7}[0.79 - 0.3] = 18\ tons$$

Looking at Table C.1, the controlling rating factor is 0.51 under the LFR method at the Inventory Level. Using Equation 6B.4.1-2, the safe load capacity is:

$$Safe\ Load\ Capacity = RFxW = (0.51)(25\ tons) = 13\ tons$$

Looking at Table C.1, the controlling rating factor is 0.58 under the ASR method at the Inventory Level. Using Equation 6B.4.1-2, the safe load capacity is:

$$Safe\ Load\ Capacity = RFxW = (0.58)(25\ tons) = 15\ tons$$

Table C.2 shows the safe posting loads for all of the legal loads to be used for posting consideration.

The R12-1 sign gives a single gross tonnage value. The load represented on this sign is the lowest safe posting load from all of the legal loads used for posting considerations. The R12-5 sign gives three truck silhouettes, with their corresponding allowable gross tonnage value. Based on our survey of Minnesota, it is assumed that the top silhouette represents the AASHTO Type 3 legal truck and the four specialized hauling vehicles, the middle silhouette represents the AASHTO Type 3S2 legal truck, and the bottom silhouette represents the AASHTO Type 3-3 legal truck.

Looking at Table C.2, the lowest safe posting load under the LRFR method is 13 tons, which corresponds to the SU7 vehicle. This load is shown on the R12-1 sign in Figure C.1. Looking at Table C.2, the lowest safe posting load of the Type 3 vehicle and the four specialized hauling vehicles is 13 tons, which corresponds to the SU7 vehicle. The safe posting loads for the Type 3S2 and Type 3-3 vehicles are 23 tons and 20 tons, respectively. These loads are shown on the R12-5 sign in Figure C.1. The posting loads for the LFR and ASR methods are determined using this same method. For the LFR and ASR methods, it is assumed that posting is done at the Inventory Level. The signs for the LFR and ASR methods can be seen in Figures C.2 and C.3, respectively.

TABLE C.1
Controlling Rating Factors

	Legal Loads for Posting Considerations													
	Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	0.79		0.75		0.65		0.72		0.64		0.60		0.53	
LFR	0.51	0.85	0.48	0.83	0.40	0.72	0.46	0.80	0.39	0.72	0.36	0.67	0.28	0.58
ASR	0.58	0.95	0.54	0.94	0.48	0.83	0.52	0.92	0.48	0.84	0.42	0.79	0.36	0.70

TABLE C.2
Safe Posting Loads

	Legal Loads for Posting Considerations													
	Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
	25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	18		23		20		16		15		15		13	
LFR	13	21	17	30	16	29	12	22	12	22	13	23	11	23
ASR	15	24	19	34	19	33	14	25	15	26	15	28	14	27

Figure C.1 Weight limit signs under LRFR method.

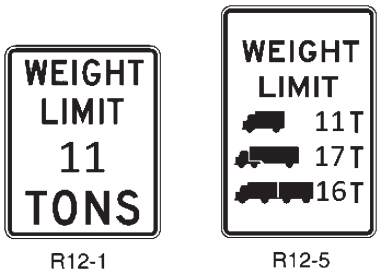


Figure C.2 Weight limit signs under LFR method.

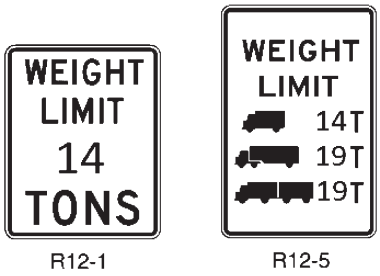


Figure C.3 Weight limit signs under ASR method.

APPENDIX D. SAMPLE BRIDGE EVALUATIONS

In order to better understand the load rating and posting procedures required by the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), and how the procedures specified in the INDOT *Bridge Inspection Manual* (INDOT, 2010), Part 3: Load Rating compare, sample bridges were evaluated. Detailed information and results of these bridge evaluations are found in this Appendix. Section D.1 gives an explanation of sample load rating results. Section D.2 discusses a single span steel bridge found in the AASHTO *MBE, 2nd Edition* (AASHTO, 2011). Section D.3 discusses a single span steel bridge provided by INDOT. Section D.4 discusses a two span steel bridge provided by INDOT, while Section D.5 discusses a three span prestressed concrete bridge provided by INDOT.

D.1 EXPLANATION OF LOAD RATING RESULTS

The sample bridges were rated using the H-20 vehicle, as well as the three AASHTO legal trucks and the four AASHTO specialized hauling vehicles, to determine if the H-20 vehicle covered all of the AASHTO loads. The sample bridges were evaluated using all three bridge load rating and evaluation methods (ASR, LFR, LRFR).

The results of each of these bridges are given in four different tables. An example of these tables is given below in Tables D.1 through D.4. The values shown in these tables are just for the purpose of this example. Table D.1 lists the calculated rating factors for the design loads. Table D.2 lists the calculated rating factors for the legal loads. Each of these tables gives the results for all three methods (ASR, LFR, LRFR) and the corresponding limit states. If a calculated rating factor is less than 1.0, the table will show a corresponding decimal value of 0. Table D.3 shows the posting loads that INDOT is currently using based on the H-20 vehicle. The INDOT *Bridge Inspection Manual* (INDOT, 2010), Part 3: Load Rating, Chapter 10 states that bridges with an inventory level capacity less than 16.0 tons for the H-20 vehicle shall be posted at the tonnage capacity. Although it is not specifically stated, it appears that the posting decisions are made based on the LFR method. Based on this, INDOT would currently post a bridge if the highlighted cell in Table D.3 is less than 16.0 tons. Table D.4 shows the safe load capacities and safe posting loads for the AASHTO legal loads. The safe load capacity is given by the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Equation 6A.4.4.4-1 (LRFR) or Equation 6B.4.1-2 (ASR and LFR). This value represents and upper bound for posting loads and is used for the ASR and LFR methods. The safe posting load is given by the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Equation 6A.8.3-1. This more conservative equation covers statistical distribution of vehicle weight, dynamic load allowance fluctuation, and vehicle weight distribution, and applies to the LRFR method. In addition, this equation only applies when a given rating factor is between 0.3 and 1.0. When the rating factor is greater than 1.0, the safe posting load is equal to the vehicle weight. When the rating factor is less than 0.3, that vehicle should not be allowed on the bridge. In this case or when the safe load capacity is less than 3 tons, the table will show a value of 0.

For an illustrative example, consider the Type 3 vehicle. For the LRFR method, the controlling rating factor is 2.32, which is highlighted in Table D.2. From here, the safe load capacity is calculated according to the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Equation 6A.4.4.4-1:

$$Safe\ Load\ Capacity = RFxW = (2.32)(25\ tons) = 58.0\ tons$$

The safe posting load is calculated according to the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Equation 6A.8.3-1:

$$Safe\ Posting\ Load = \frac{W}{0.7}[(RF) - 0.3] = \frac{25\ tons}{0.7}[2.32 - 0.3] = 25.0\ tons$$

In this case, the safe posting load is equal to the weight of the vehicle because the rating factor is greater than 1.0. This means that the Type 3 vehicle does not need to be posted for under the LRFR method. The safe load capacities and safe posting loads are shown for all of the AASHTO legal vehicles in Table D.4.

This same process is used for the ASR and LFR methods, but only the safe load capacity is used.

D.2 SINGLE SPAN STEEL BRIDGE EVALUATION (AASHTO)

This sample bridge is found in the AASHTO *MBE, 2nd Edition* (AASHTO, 2011), Appendix A. This bridge was first analyzed to understand the load rating and posting process prescribed by the AASHTO *MBE, 2nd Edition*. The entire load rating and posting analysis is shown in Appendix A of the AASHTO *MBE, 2nd Edition*; therefore, the load rating and posting calculations could easily be verified. Once the load rating and posting calculations were verified, the bridge span was artificially increased by 5 ft increments to correspondingly increase the bending moment and then evaluate the resulting load posting values. The results for span lengths of 65 ft, 80 ft, and 90 ft are shown in this Appendix.

Bridge Criteria (Figures D.1 and D.2)

Year of Construction = 1964
Girder Yield Strength, F_y = 36.0 ksi
Girder Elastic Mod., E_G = 29000.0 ksi
Deck Comp. Strength, f'_c = 3000 psi
Deck Thickness, t_D = 7.25″
Diaphragm Spacing, s_D = 16′-3″

TABLE D.1
Rating Factors for Design Load

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	1.29	1.68	—	—	2.92	
		She	2.43	3.16	—	—	5.78	
	Service II		1.21	1.57	—	—	2.58	
	Fatigue		0.40	—	—	—	—	
LFR	Strength		—	—	1.33	2.21	1.99	3.33
	Service		—	—	1.18	1.97	1.77	2.96
ASR			—	—	0.72	1.34	1.07	2.02

TABLE D.2
Rating Factors for Legal Loads

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	2.64		2.47		2.71		2.76		2.50		2.25		2.07	
		She	5.00		4.31		4.37		5.36		4.79		4.47		4.47	
	Service II		2.32		2.18		2.38		2.06		1.87		1.68		1.54	
	Fatigue		—		—		—		—		—		—		—	
LFR	Strength		1.80	3.00	1.68	2.81	1.84	3.08	1.59	2.66	1.45	2.41	1.30	2.17	1.19	1.99
	Service		1.60	2.67	1.50	2.51	1.64	2.73	1.42	2.36	1.29	2.15	1.15	1.93	1.06	1.77
ASR			0.97	1.82	0.92	1.71	1.00	1.86	0.86	1.61	0.78	1.46	0.70	1.31	0.64	1.21

TABLE D.3
INDOT Posting Load

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	51.6	
LFR	Safe Load Capacity	35.4	59.2
ASR	Safe Load Capacity	21.4	40.4

TABLE D.4
AASHTO Posting Loads

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	58.0		78.5		95.2		55.6		58.0		58.4		59.7	
	Safe Posting Load	25.0		36.0		40.0		27.0		31.0		34.8		38.8	
LFR	Safe Load Capacity	40.0	66.8	54.0	90.4	65.6	109.2	38.3	63.7	40.0	66.7	40.0	67.1	41.1	68.6
ASR	Safe Load Capacity	24.3	45.5	33.1	61.6	40.0	74.4	23.2	43.5	24.2	45.3	24.3	45.5	24.8	46.9

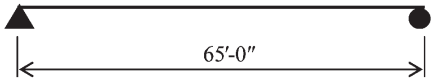


Figure D.1 Bridge span.

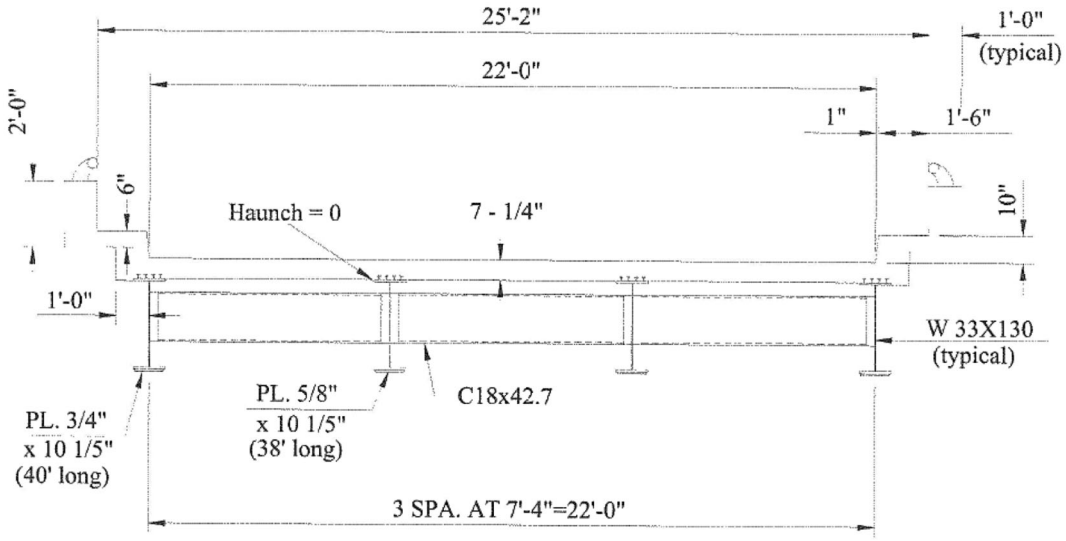


Figure D.2 Bridge cross-section (AASHTO, 2011).

Results

Tables D.5 through D.8 provide the results for the 65 ft span. As can be seen in Table D.6, all of the rating factors are greater than 1.0 for the LRFR and LFR methods; therefore, posting is not required. Several rating factors are less than 1.0 at the inventory level for the ASR method. Posting is not required unless a rating factor is less than 1.0 at the operating level; therefore, posting is not required.

Tables D.9 through D.12 give the results for the 80 ft span. Looking at Table D.10, posting is required for the LRFR and LFR methods, while the bridge should be closed based on the ASR method. Looking at Table D.11, INDOT would currently not be posting this bridge because the H-20 safe load capacity at inventory level is 16.6 tons (shown by the shaded cell), which is greater than 16 tons. This clearly presents a problem as posting is required, but INDOT would not currently be posting this bridge.

Tables D.13 through D.16 give the results for the 90 ft span. Looking at Table D.14, posting is required for the LRFR and LFR methods, while the bridge should be closed based on the ASR method. Looking at Table D.15, INDOT would currently be posting this bridge at 8.2 tons (shown by the shaded cell). Looking at Table D.16, if the LRFR method were used, several vehicles have a safe posting load less than 8.2 tons. Again, this is a problem because even though INDOT would post this bridge, the posted load would not cover all of the AASHTO legal loads.

D.3 SINGLE SPAN STEEL BRIDGE EVALUATION (INDOT)

This sample bridge was provided by INDOT. This bridge was analyzed to evaluate an additional bridge type (i.e. other than hot-rolled steel girders).

Bridge Criteria (Figures D.3 through D.7)

Year of Construction = Unknown (Post 2012)
Design Methodology = LRFD
Girder Yield Strength, F_y = 50.0 ksi
Girder Elastic Mod., E_G = 29000.0 ksi
Deck Comp. Strength, f'_c = 4000 psi
Deck Thickness, t_D = 8″
Diaphragm Spacing, s_D = 13′-9″

Results

Tables D.17 through D.20 show the bridge evaluation results. As can be noted in Table D.17, all of the rating factors are greater than 1.0 for the LRFR and LFR methods; therefore, posting is not required. Several rating factors are less than 1.0 at the inventory level for the ASR method. Posting is not required unless

TABLE D.5
Rating Factors for Design Loads (65 ft Span)

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	1.29	1.68	—	—	2.92	
		She	2.43	3.16	—	—	5.78	
	Service II		1.21	1.57	—	—	2.58	
	Fatigue		0.40	—	—	—	—	
LFR	Strength		—	—	1.33	2.21	1.99	3.33
	Service		—	—	1.18	1.97	1.77	2.96
ASR			—	—	0.72	1.34	1.07	2.02

TABLE D.6
Rating Factors for Legal Loads (65 ft Span)

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	2.64		2.47		2.71		2.76		2.50		2.25		2.07	
		She	5.00		4.31		4.37		5.36		4.79		4.47		4.47	
	Service II		2.32		2.18		2.38		2.06		1.87		1.68		1.54	
	Fatigue		—		—		—		—		—		—		—	
LFR	Strength		1.80	3.00	1.68	2.81	1.84	3.08	1.59	2.66	1.45	2.41	1.30	2.17	1.19	1.99
	Service		1.60	2.67	1.50	2.51	1.64	2.73	1.42	2.36	1.29	2.15	1.15	1.93	1.06	1.77
ASR			0.97	1.82	0.92	1.71	1.00	1.86	0.86	1.61	0.78	1.46	0.70	1.31	0.64	1.21

TABLE D.7
INDOT Posting Load (65 ft Span)

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	51.6	
LFR	Safe Load Capacity	35.4	59.2
ASR	Safe Load Capacity	21.4	40.4

TABLE D.8
AASHTO Posting Loads (65 ft Span)

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	58.0		78.5		95.2		55.6		58.0		58.4		59.7	
	Safe Posting Load	25.0		36.0		40.0		27.0		31.0		34.8		38.8	
LFR	Safe Load Capacity	40.0	66.8	54.0	90.4	65.6	109.2	38.3	63.7	40.0	66.7	40.0	67.1	41.1	68.6
ASR	Safe Load Capacity	24.3	45.5	33.1	61.6	40.0	74.4	23.2	43.5	24.2	45.3	24.3	45.5	24.8	46.9

TABLE D.9
Rating Factors for Design Loads (80 ft Span)

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	0.75	0.98	—	—	1.84	
		She	2.09	2.71	—	—	5.28	
	Service II		0.56	0.73	—	—	1.29	
	Fatigue		0.39	—	—	—	—	
LFR	Strength		—	—	0.73	1.21	1.13	1.89
	Service		—	—	0.53	0.89	0.83	1.39
ASR			—	—	0.00	0.39	0.00	0.61

TABLE D.10
Rating Factors for Legal Loads (80 ft Span)

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	1.62		1.42		1.45		1.71		1.54		1.38		1.26	
		She	4.50		3.69		3.63		4.84		4.30		3.98		3.70	
	Service II		1.14		1.00		1.02		1.02		0.92		0.82		0.75	
	Fatigue		—		—		—		—		—		—		—	
LFR	Strength		1.00	1.67	0.87	1.46	0.90	1.50	0.89	1.49	0.80	1.34	0.72	1.20	0.66	1.10
	Service		0.73	1.22	0.64	1.07	0.66	1.10	0.65	1.09	0.59	0.98	0.53	0.88	0.48	0.80
ASR			0.00	0.53	0.00	0.48	0.00	0.48	0.00	0.48	0.00	0.43	0.00	0.38	0.00	0.35

TABLE D.11
INDOT Posting Load (80 ft Span)

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	25.8	
LFR	Safe Load Capacity	16.6	27.8
ASR	Safe Load Capacity	0.0	12.1

TABLE D.12
AASHTO Posting Loads (80 ft Span)

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	28.5		36.0		40.8		27.5		28.5		28.5		29.1	
	Safe Posting Load	25.0		36.0		40.0		27.0		27.5		25.8		24.9	
LFR	Safe Load Capacity	18.3	30.5	23.0	38.5	26.4	44.0	17.6	29.4	18.3	30.4	18.4	30.6	18.6	31.0
ASR	Safe Load Capacity	0.0	13.3	0.0	17.3	0.0	19.2	0.0	13.0	0.0	13.3	0.0	13.2	0.0	13.6

TABLE D.13
Rating Factors for Design Loads (90 ft Span)

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	0.50	0.65	—	—	1.28	
		She	1.96	2.54	—	—	5.11	
	Service II		0.28	0.36	—	—	0.66	
	Fatigue		0.38	—	—	—	—	
LFR	Strength		—	—	0.48	0.80	0.76	1.27
	Service		—	—	0.26	0.44	0.41	0.69
ASR			—	—	0.00	0.00	0.00	0.00

TABLE D.14
Rating Factors for Legal Loads (90 ft Span)

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	1.11		0.94		0.94		1.17		1.05		0.94		0.86	
		She	4.32		3.47		3.37		4.66		4.13		3.80		3.52	
	Service II		0.57		0.49		0.49		0.51		0.46		0.41		0.37	
	Fatigue		—		—		—		—		—		—		—	
LFR	Strength		0.66	1.10	0.56	0.94	0.56	0.94	0.59	0.99	0.53	0.89	0.48	0.80	0.43	0.72
	Service		0.36	0.60	0.31	0.52	0.31	0.51	0.32	0.54	0.29	0.48	0.26	0.43	0.23	0.39
ASR			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE D.15
INDOT Posting Load (90 ft Span)

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	13.2	
LFR	Safe Load Capacity	8.2	13.8
ASR	Safe Load Capacity	0.0	0.0

TABLE D.16
AASHTO Posting Loads (90 ft Span)

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	14.3		17.6		19.6		13.8		14.3		14.3		14.3	
	Safe Posting Load	9.6		9.8		10.9		8.1		7.1		5.5		3.9	
LFR	Safe Load Capacity	9.0	15.0	11.2	18.7	12.4	20.4	8.6	14.6	9.0	14.9	9.0	14.9	8.9	15.1
ASR	Safe Load Capacity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

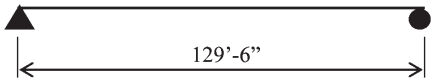


Figure D.3 Bridge span.

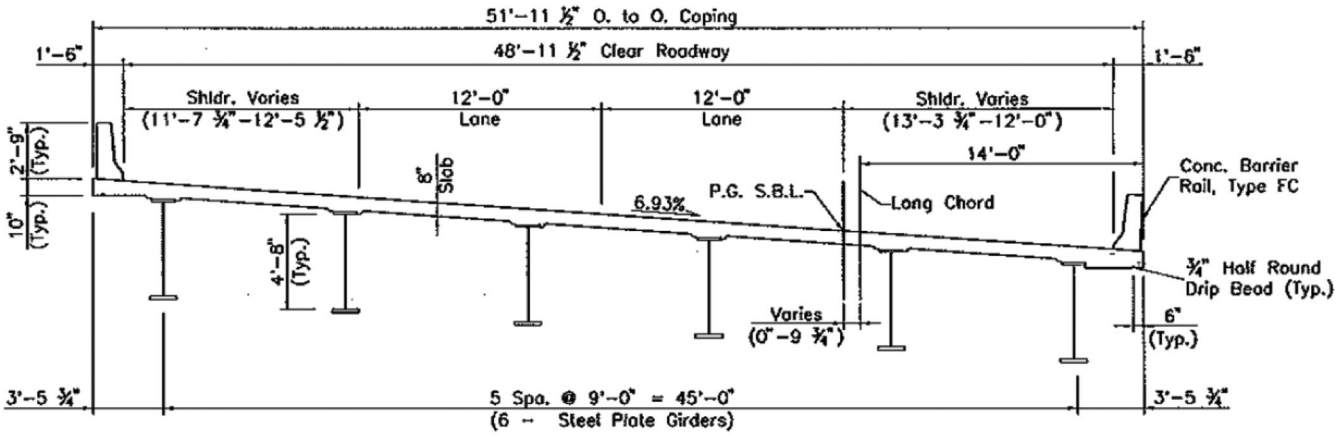


Figure D.4 Bridge cross-section (INDOT, 2011).

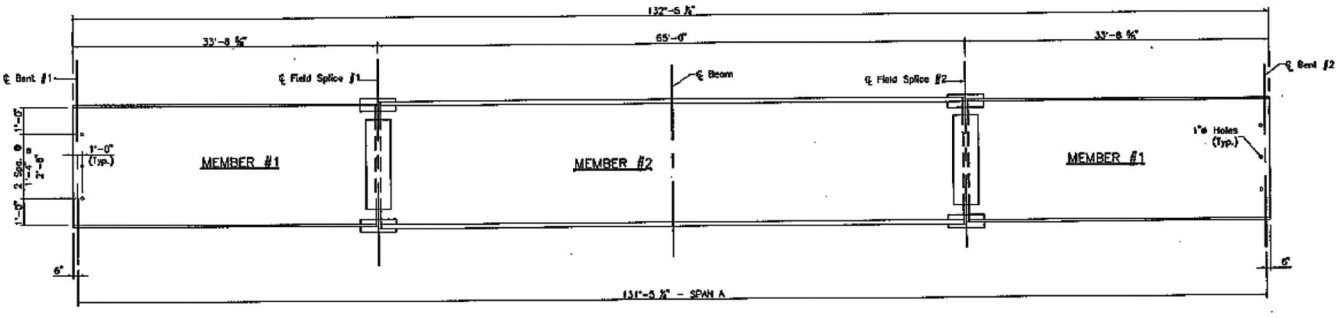


Figure D.5 Girder elevation (INDOT, 2011). (Note the girder lengths vary).

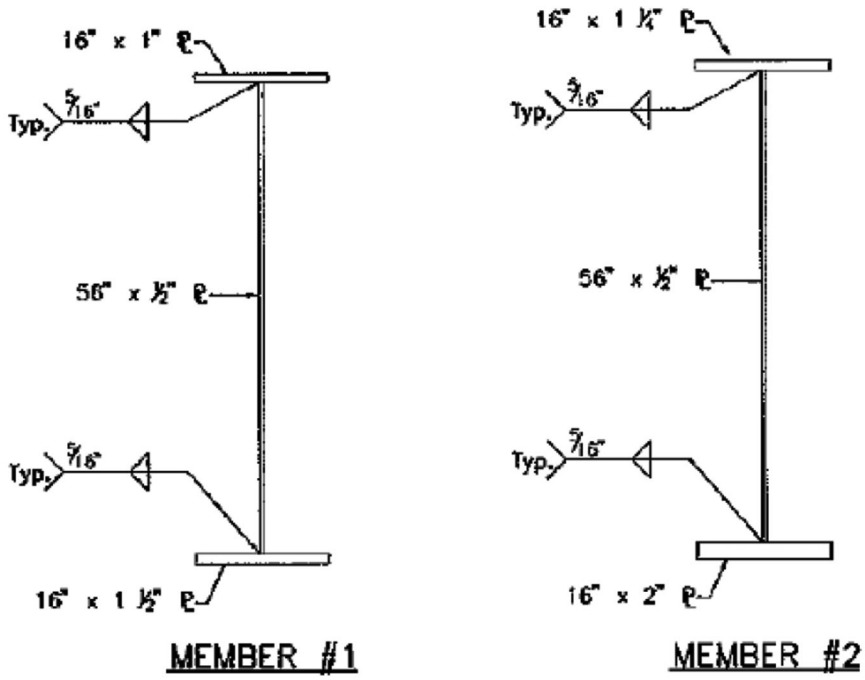


Figure D.6 Girder cross-sections (INDOT, 2011).

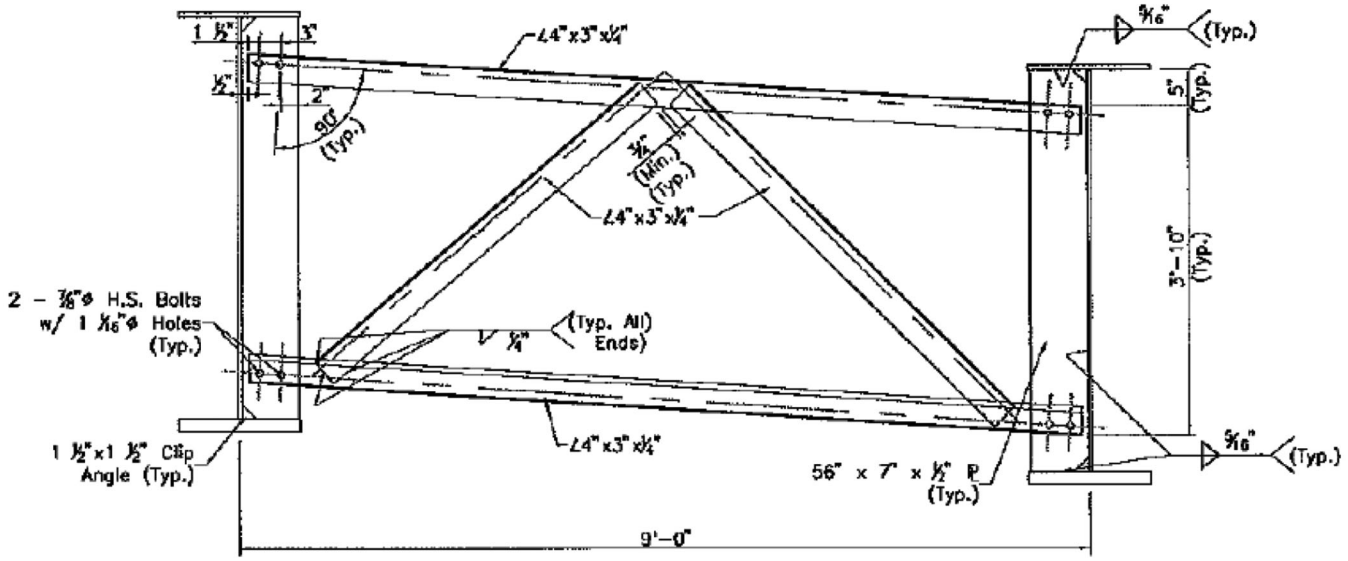


Figure D.7 Typical diaphragm (INDOT, 2011).

a rating factor is less than 1.0 at the operating level; therefore, posting is not required.

For this bridge, the rating factors calculated for the H-20 vehicle (Table D.17) are greater than the rating factors calculated for the AASHTO legal loads (Table D.18). Due to this, it is possible that posting would be required for the AASHTO legal loads before posting would be required for the H-20 for this bridge structure.

Also, looking at Tables D.17 and D.18, it is observed that the rating factors calculated under the ASR method are less than the rating factors calculated under the LRFR and LFR methods. While posting is not required at this point, if this trend continued, posting would be required under the ASR method before posting would be required under the LRFR and LFR methods.

D.4 TWO SPAN STEEL BRIDGE EVALUATION (INDOT)

This sample bridge was provided by INDOT. This bridge was analyzed to evaluate a continuous span bridge and to evaluate a bridge designed by a method other than LRFD.

Bridge Criteria (Figures D.8 through D.12)

Year of Construction = 1971
Design Methodology = ASD
Girder Yield Strength, F_y = 36.0 ksi
Girder Elastic Mod., E_G = 29000.0 ksi
Deck Comp. Strength, f'_c = 3500 psi
Deck Thickness, t_D = 8″
Wearing Surface, t_W = 2″
Diaphragm Spacing, s_D = 25′-0″

Results

Tables D.21 through D.24 show the bridge evaluation results. A "NC" means that the section evaluated is noncomposite, while a "C" means that the section evaluated is composite. Looking at Table D.21, there are rating factors below 1.0 under all three methods, meaning that the legal loads need to be evaluated. Looking at Table D.22, there are rating factors below 1.0 under all three methods, meaning that posting is required. The strength rating factors in the positive moment region for the LRFR method are low due to a slender compression flange. For the LFR method, the positive moment region is not evaluated because provisions are not given for this case in the AASHTO *Standard Specifications for Highway Bridges, 17th Edition* (AASHTO, 2002).

Under the LRFR method, if the R12-1 single gross tonnage sign were used, it was determined that the bridge would need to be posted for a load of 12 tons. According to the inspection report, the bridge is currently posted for a value of 6 tons (INDOT, 2012). It is unknown if this value was determined by calculation, or if the bridge was posted at a severe weight restriction until retrofits are made.

TABLE D.17
Rating Factors for Design Loads

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	1.55	2.00	—	—	4.49	
		She	1.54	2.00	—	—	4.53	
	Service II		1.48	1.92	—	—	4.04	
LFR	Strength		—	—	1.46	2.44	2.42	4.04
	Service		—	—	1.37	2.29	2.27	3.79
ASR			—	—	0.28	1.28	0.46	2.13

TABLE D.18
Rating Factors for Legal Loads

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Strength I	Flex	3.80		3.00		2.88		4.06		3.61		3.23		2.92	
		She	3.76		2.88		2.72		4.07		3.59		3.27		3.00	
	Service II		3.42		2.70		2.59		3.10		2.75		2.46		2.23	
LFR	Strength		2.05	3.42	1.62	2.70	1.55	2.59	1.86	3.10	1.65	2.75	1.48	2.46	1.34	2.23
	Service		1.92	3.21	1.52	2.54	1.46	2.43	1.74	2.91	1.55	2.59	1.38	2.31	1.25	2.10
ASR			0.39	1.80	0.31	1.42	0.29	1.36	0.35	1.63	0.31	1.45	0.28	1.30	0.25	1.17

TABLE D.19
INDOT Posting Load

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	80.8	
LFR	Safe Load Capacity	45.4	75.8
ASR	Safe Load Capacity	9.2	42.6

TABLE D.20
AASHTO Posting Loads

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	85.5		97.2		103.6		83.7		85.3		85.5		86.4	
	Safe Posting Load	25.0		36.0		40.0		27.0		31.0		34.8		38.8	
LFR	Safe Load Capacity	48.0	80.3	54.7	91.4	58.4	97.2	47.0	78.6	48.1	80.3	48.0	80.3	48.4	81.4
ASR	Safe Load Capacity	9.8	45.0	11.2	51.1	11.6	54.4	9.5	44.0	9.6	45.0	9.7	45.2	9.7	45.3

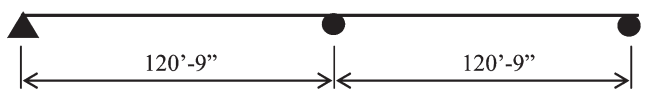


Figure D.8 Bridge span.

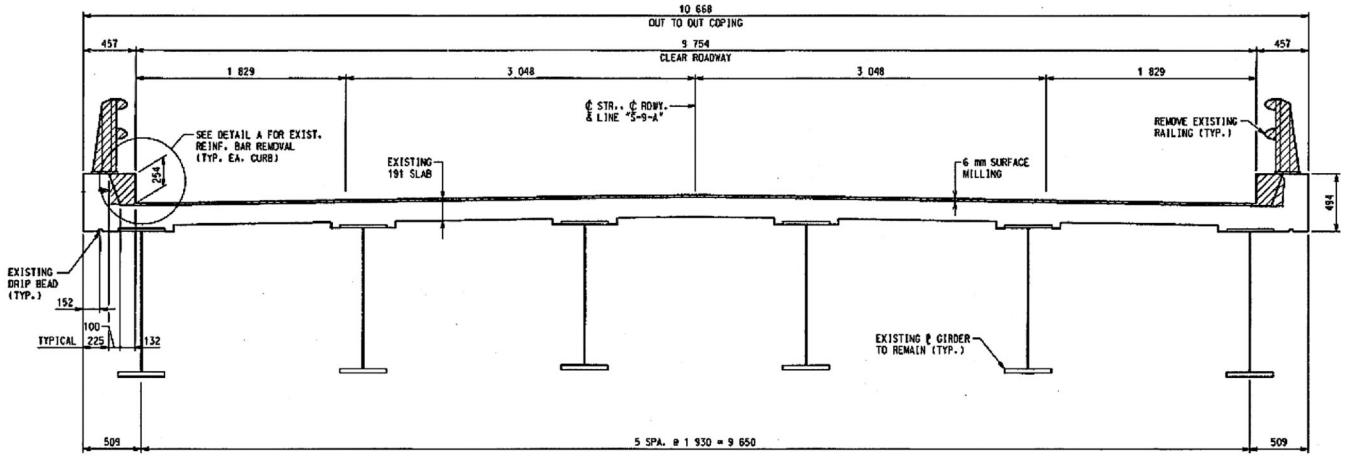


Figure D.9 Bridge cross-section (INDOT, 1999).

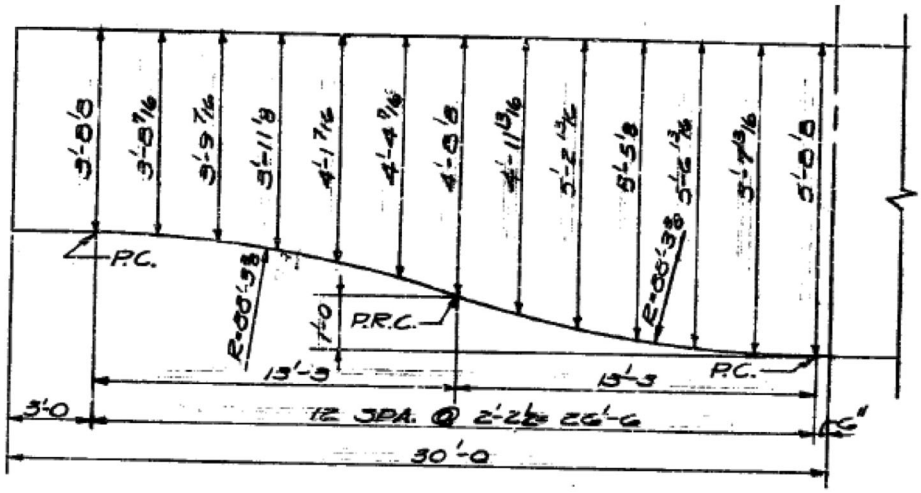


Figure D.10 Girder web elevation at pier (INDOT, 1969).

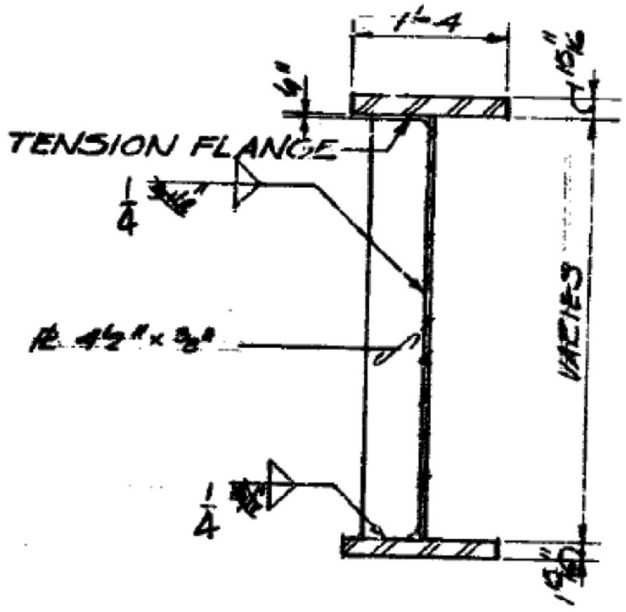


Figure D.11 Typical girder cross-section (INDOT, 1969).

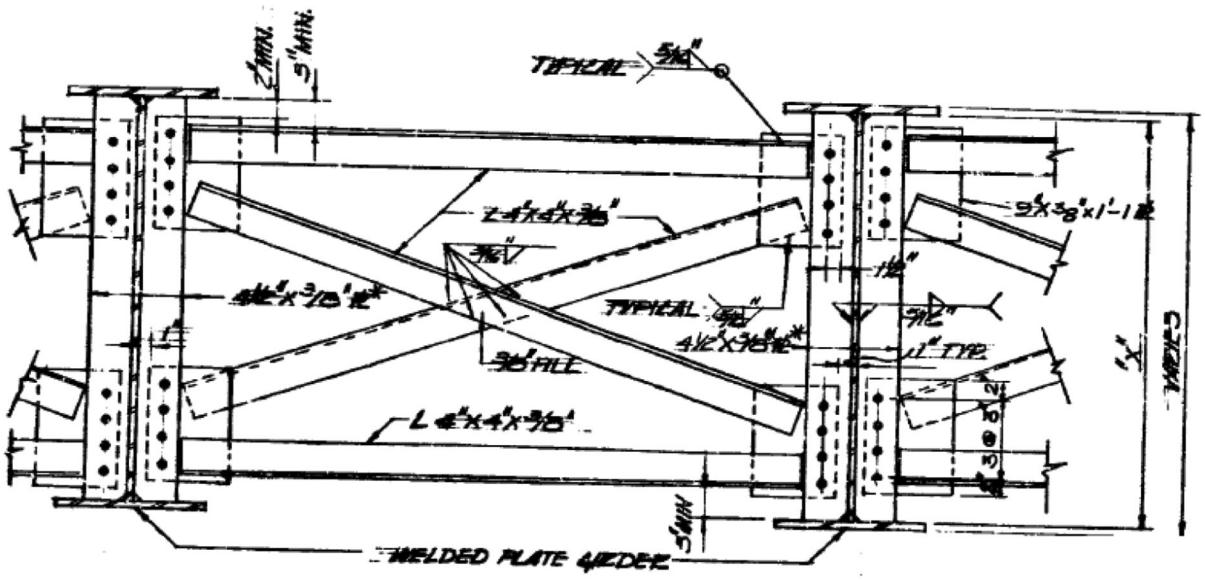


Figure D.12 Typical diaphragm (INDOT, 1969).

TABLE D.21
Rating Factors for Design Loads

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Stre I	Neg (NC)	0.55	0.71	—	—	4.92	
		Pos (NC)	0.26	0.34	—	—	0.86	
		Shear	1.96	2.54	—	—	12.70	
	Serv II	Neg (NC)	1.08	1.41	—	—	7.78	
		Pos (C)	1.64	2.13	—	—	4.09	
LFR	Stre	Neg (NC)	—	—	0.69	1.15	3.11	5.19
		Pos (NC)	—	—	x	x	x	x
		Shear	—	—	2.19	3.66	5.10	8.51
	Serv	Neg (NC)	—	—	1.26	2.10	5.69	9.50
		Pos (C)	—	—	1.81	3.02	2.73	4.56
ASR		Neg (NC)	—	—	0.76	1.83	3.45	8.29
		Pos (C)	—	—	1.17	2.09	1.78	3.17

TABLE D.22
Rating Factors for Legal Loads

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Stre I	Neg (NC)	2.99		2.19		1.13		2.48		2.24		2.15		1.94	
		Pos (NC)	0.79		0.75		0.65		0.72		0.64		0.60		0.53	
		Shear	10.16		7.16		3.74		9.41		8.19		7.36		6.60	
	Serv II	Neg (NC)	4.73		3.47		1.79		3.93		3.54		3.40		3.07	
		Pos (C)	3.76		3.24		3.05		3.40		3.03		2.76		2.49	
LFR	Stre	Neg (NC)	1.89	3.16	1.39	2.32	0.71	1.19	1.57	2.62	1.41	2.36	1.36	2.27	1.23	2.05
		Pos (NC)	×	×	×	×	×	×	×	×	×	×	×	×	×	×
		Shear	4.08	6.81	2.87	4.80	1.50	2.50	3.78	6.31	3.29	5.49	2.96	4.93	2.65	4.42
	Serv	Neg (NC)	3.46	5.77	2.54	4.24	1.30	2.18	2.87	4.79	2.59	4.32	2.49	4.15	2.24	3.74
		Pos (C)	2.51	4.20	2.17	3.62	2.04	3.41	2.27	3.80	2.02	3.38	1.84	3.07	1.67	2.78
ASR		Neg (NC)	2.10	5.04	1.54	3.70	0.79	1.90	1.74	4.18	1.57	3.77	1.51	3.62	1.36	3.26
		Pos (C)	1.64	2.92	1.48	2.55	1.33	2.37	1.48	2.64	1.31	2.35	1.22	2.15	1.09	1.94

TABLE D.23
INDOT Posting Load

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	17.2	
LFR	Safe Load Capacity	54.6	91.2
ASR	Safe Load Capacity	35.6	63.4

Because this bridge has a slender compression flange, it is difficult to determine an accurate relationship between the H-20 vehicle and the AASHTO legal loads or between the three methods.

D.5 THREE SPAN P/S CONCRETE BRIDGE EVALUATION (INDOT)

This sample bridge was provided by INDOT. This bridge was analyzed to evaluate a continuous span bridge and to evaluate an additional bridge type.

Bridge Criteria (Figures D.13 through D.16)

Year of Construction = Unknown (Post 2008)
Design Methodology = LRFD
Comp. Strength Trans, f'_{ci} = 6500 psi
Comp. Strength Serv, f'_c = 8000 psi
Girder Area, A = 1221 in^2
Girder Moment Inertia, I = 1115573 in^4
Area P/S Strand, A_{ps} = 0.217 in^2
P/S Strand Strength, f_{pu} = 270 ksi (Low-Lax)
P/S Strand Ends = 22 (End Spans), g = 8.45″
P/S Strand Mid = 20 (End Spans), g = 2.30″
P/S Strand Ends = 56 (Middle Span), g = 16.46″
P/S Strand Mid = 54 (Middle Span), g = 4.15″
Deck Comp. Strength, f'_c = 3500 psi
Deck Thickness, t_D = 8″
Reinf. Strength, f_y = 60 ksi
Neg. Mom. Reinf. = (2) #7 and (2) #5 bars per foot
Diaphragm Spacing, s_D = 46′-6″ (End Spans) 36′-0″ (Middle Span)

Results

Tables D.25 through D.28 show the bridge evaluation results. Results are not shown for the ASR method, because the load rating of prestressed concrete members is a combination of the LFR and ASR methods according to the AASHTO *MBE, 2nd Edition*, Section 6B.5.2.5 (AASHTO, 2011). Looking at Table D.25, all of the rating factors are greater than 1.0 for the LRFR and LFR methods; therefore, posting is not required.

For this bridge, the rating factors calculated for the H-20 vehicle (Table D.25) are greater than the rating factors calculated for the AASHTO legal loads (Table D.26). Due to this, it is possible that posting would be required for the AASHTO legal loads before posting would be required for the H-20.

TABLE D.24
AASHTO Posting Loads

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	19.8		27.0		26.0		19.4		19.8		20.9		20.5	
	Safe Posting Load	17.5		23.1		20.0		16.2		15.1		14.9		12.7	
LFR	Safe Load Capacity	47.3	79.0	50.0	83.5	28.4	47.6	42.4	70.7	43.7	73.2	47.3	78.9	47.7	79.4
ASR	Safe Load Capacity	41.0	73.0	53.3	91.8	31.6	76.0	40.0	71.3	40.6	72.9	42.4	74.7	42.2	75.2

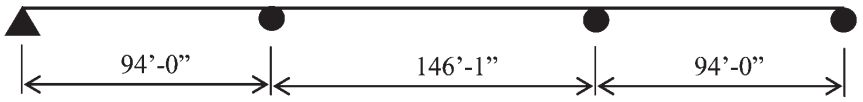


Figure D.13 Bridge span.

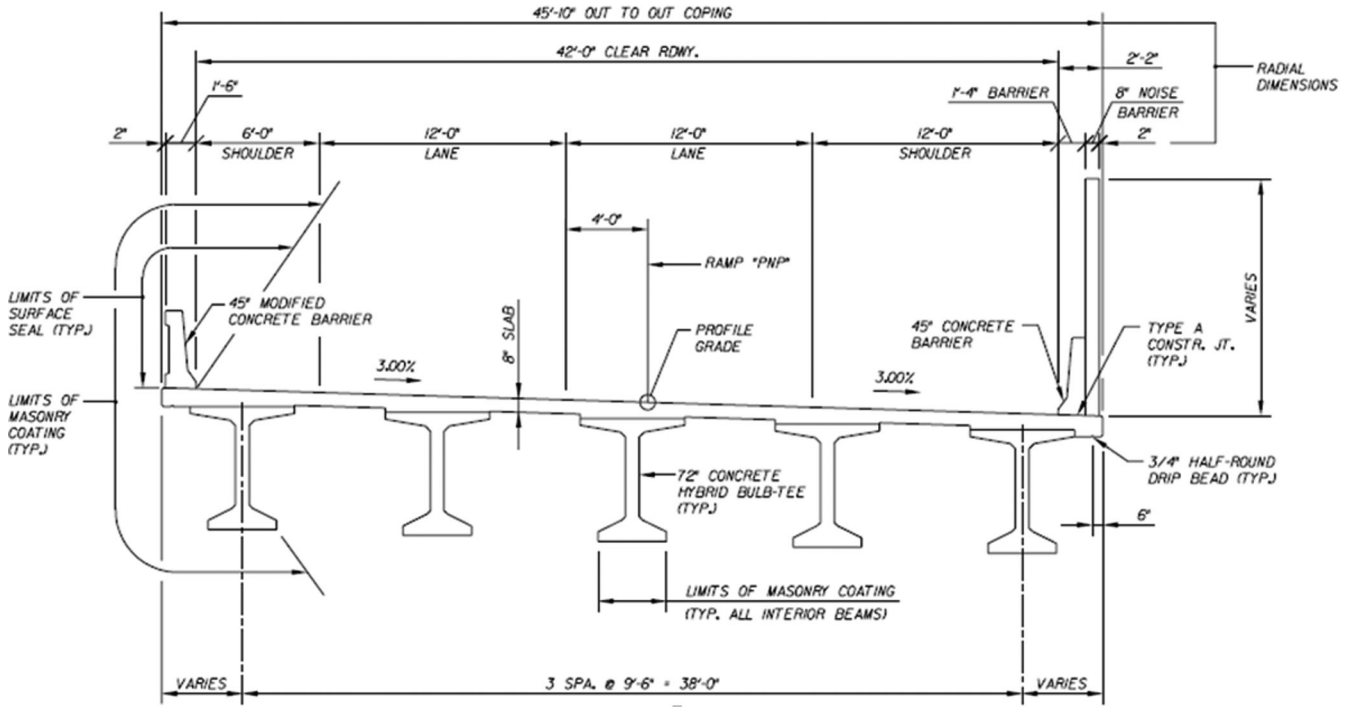


Figure D.14 Bridge cross-section (INDOT, 2008).

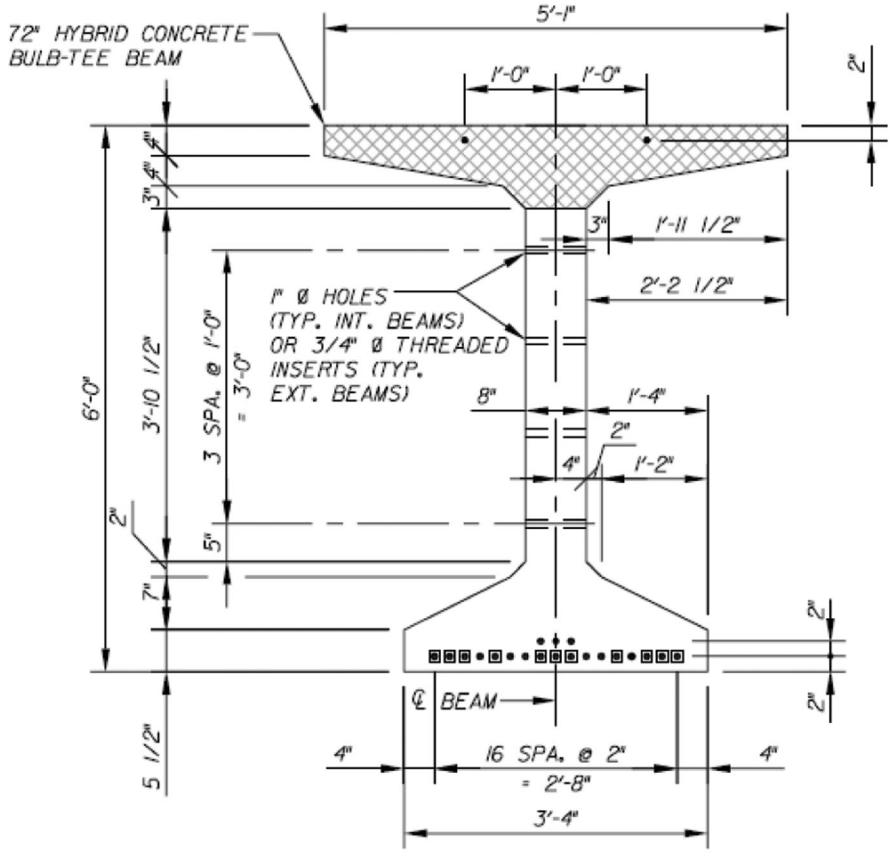


Figure D.15 Typical girder cross-section (INDOT, 2008).

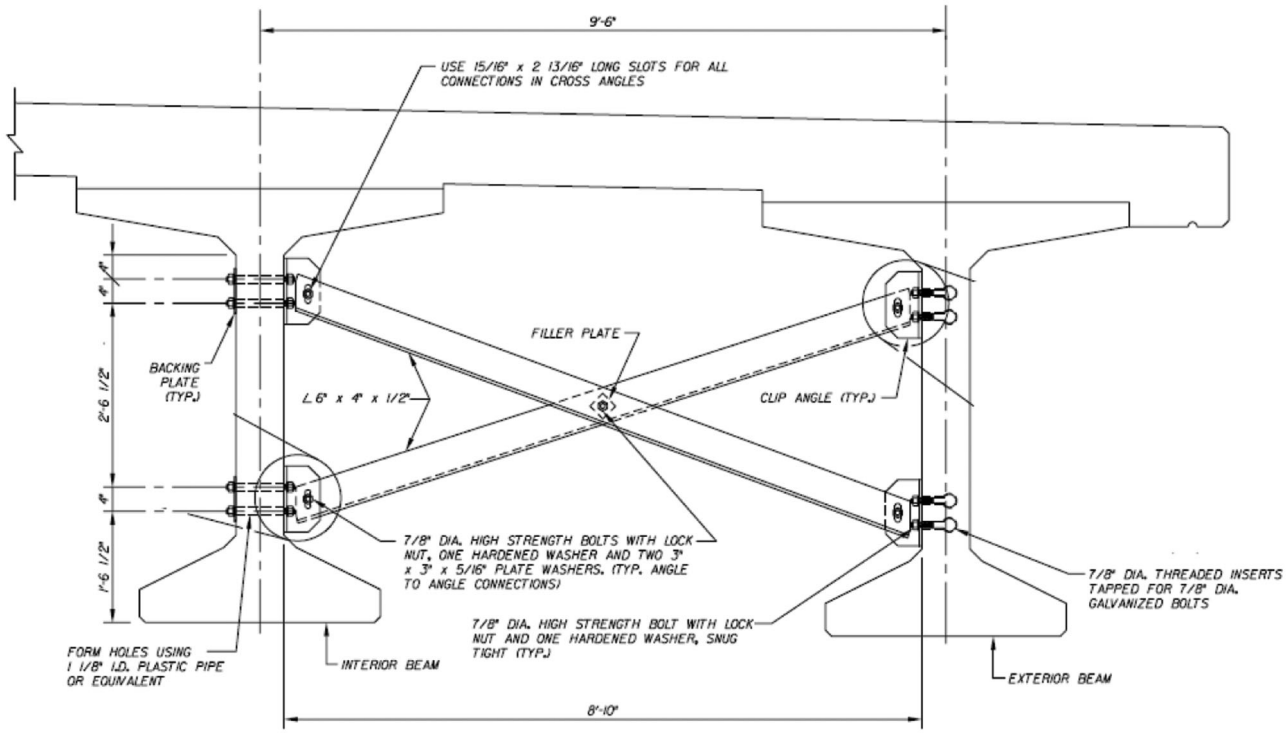


Figure D.16 Typical diaphragm (INDOT, 2008).

TABLE D.25
Rating Factors for Design Loads

			Design Loads					
			HL-93		HS-20		H-20	
			Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Stre I	Neg	1.65	2.14	—	—	6.88	
		Pos	1.79	2.32	—	—	4.16	
	Serv III	Neg	2.83	—	—	—	6.38	
		Pos	2.76	—	—	—	5.22	
LFR	Strength	Neg	—	—	1.33	2.23	3.61	6.02
		Pos	—	—	1.32	2.21	2.09	3.48
	Service	Neg	—	—	3.26	—	8.83	—
		Pos	—	—	1.88	—	2.60	—
ASR		Neg	—	—	—	—	—	—
		Pos	—	—	—	—	—	—

TABLE D.26
Rating Factors for Legal Loads

			Legal Loads for Posting Considerations													
			Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
			Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Stre I	Neg	5.56		4.03		2.61		5.12		4.48		4.00		3.60	
		Pos	3.65		3.07		3.20		3.27		2.94		2.63		2.40	
	Serv II	Neg	5.16		3.74		2.46		4.74		4.16		3.71		3.34	
		Pos	4.57		3.85		4.01		4.10		3.69		3.30		3.01	
LFR	Stre	Neg	2.91	4.86	2.11	3.52	1.37	2.28	2.68	2.73	2.35	3.92	2.10	3.50	1.89	3.15
		Pos	1.83	3.05	1.54	2.57	1.60	2.68	1.64	5.76	1.47	2.46	1.32	2.20	1.20	2.01
	Serv	Neg	7.13	—	5.17	—	3.35	—	6.56	—	5.75	—	5.13	—	4.62	—
		Pos	2.24	—	1.82	—	1.78	—	2.02	—	1.81	—	1.62	—	1.47	—
ASR		Neg	—	—	—	—	—	—	—	—	—	—	—	—	—	—
		Pos	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE D.27
INDOT Posting Load

		H-20	
		20 tons	
		Inv	Oper
LRFR	Safe Load Capacity	83.2	
LFR	Safe Load Capacity	41.8	69.6
ASR	Safe Load Capacity	—	—

TABLE D.28
AASHTO Posting Loads

		Type 3		Type 3S2		Type 3-3		SU4		SU5		SU6		SU7	
		25 tons		36 tons		40 tons		27 tons		31 tons		34.75 tons		38.75 tons	
		Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper	Inv	Oper
LRFR	Safe Load Capacity	91.3		110.5		96.8		88.3		91.1		91.4		93.0	
	Safe Posting Load	25.0		36.0		40.0		27.0		31.0		34.8		38.8	
LFR	Safe Load Capacity	45.8	76.3	55.4	92.5	54.8	91.2	44.3	73.7	45.6	76.3	45.9	76.5	46.5	77.9
ASR	Safe Load Capacity	—	—	—	—	—	—	—	—	—	—	—	—	—	—

APPENDIX E. RECOMMENDED LANGUAGE

INDOT's current *Bridge Inspection Manual* (INDOT, 2010), Part 3: Load Rating, has limited guidance and requirements on load rating and posting. After reviewing other state DOT manuals and AASHTO manuals, it is clear that the INDOT *Bridge Inspection Manual*, Part 3: Load Rating needs to be modified to include more load rating and posting guidance in order to eliminate current deficiencies.

Appendix E shows how recommended language can be implemented into the INDOT *Bridge Inspection Manual* (INDOT, 2010), Part 3: Load Rating. This appendix is broken down into subsections for various chapters of the manual. Section E.1 is for general load rating and posting guidelines. Section E.2 is for the ASR method. Section E.3 is for the LFR method. Section E.4 is for the LRFR method. Section E.5 is for the rating vehicles. Section E.6 is for load posting guidelines.

Much of the recommended language is modeled after requirements in the Washington State Department of Transportation (WSDOT) *Bridge Design Manual* (WSDOT, 2012), the Wisconsin Department of Transportation (WisDOT) *WisDOT Bridge Manual* (WisDOT, 2013), and the AASHTO *MBE, 2nd Edition* (AASHTO, 2011). (*Appendix continues on next page.*)

E.1 GENERAL LOAD RATING AND POSTING GUIDELINES

RECOMMENDED CHAPTER 1 INTRODUCTION

With the Federal Highway Administration's (FHWA's) adoption of the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Specifications, the FHWA has issued a clarification of policy regarding the appropriate methodology and loads to be used in operating and inventory rating data. It is necessary to accommodate and support Load and Resistance Factor Rating (LRFR), while continuing to accept Allowable Stress Rating (ASR) and Load Factor Rating (LFR) for the large inventory of in-service bridges that have been designed by a method other than LRFD. The AASHTO *Manual for Bridge Evaluation, Second Edition* is the current manual for bridge evaluation. Although the manual emphasizes the LRFR method, it also provided rating procedures for the ASR and LFR methodologies. For this reason, it will be the governing manual utilized by INDOT for load rating structures.

Bridge load ratings are currently performed for specific purposes such as: National Bridge Inventory (NBI) reporting, overweight permit load checks, bridge rehabilitation, etc. However, the main purpose of load rating is to determine the safe live load capacity of a structure. Conditions of bridges change over time, resulting in the need for re-evaluation of the load rating. The actual capacity depends on many factors, such as the gross vehicle weight, the axle configuration, the distribution of loads between the axles, etc. Since it is not practical to rate a bridge for the nearly infinite number of axle configurations of trucks on our highways, bridges are rated for standard vehicles which are representative of the actual vehicles in use today. These standard vehicles will be discussed later in this document.

The FHWA currently requires that two capacity ratings, referred to as the Inventory Rating and Operating Rating be submitted with the NBI file. The FHWA requires that the standard AASHTO HS truck or lane loading be used as the vehicle when load rating with the ASR and LFR methods; and that the AASHTO HL-93 loading be utilized as the vehicle when load rating with the LRFR method. A guide for when to utilize each method can be found in Chapters A-C.

The primary purpose of this manual is to establish a uniform policy of load rating procedures and standards for the posting of bridges within the state of Indiana. This will ensure every bridge is rated as to its safe load-carrying capacity. ~~When the maximum unrestricted legal loads or state routine permit loads exceed the inventory rating or equivalent rating factor, those bridges shall be posted or restricted in accordance with the AASHTO or state law~~.

This part of the manual is a reference tool for rating bridges. It outlines guidelines and procedures for load rating and the documentation required. Although this is intended to be used for the load rating of bridges, many of the processes and procedures can be applied to small structures not classified by 23CFR650 as a bridge.

E.2 ALLOWABLE STRESS RATING GUIDELINES

There is currently not a section that discusses the ASR method.

RECOMMENDED CHAPTER A ALLOWABLE STRESS RATING (ASR) METHOD

The ASR method is not used for load rating and posting.

(*If ASR is not to be used)

All existing structures designed by the Allowable Stress Design (ASD) method shall be rated utilizing the ASR method per the AASHTO *Manual for Bridge Evaluation, Second Edition*, Section 6B.

There are three potential checks to be made in ASR that are detailed in the flow chart shown in Figure A.1. For purposes of calculating the Inventory and Operating rating of the structure, the live load to be used shall be the HS-20 truck or lane loading as shown in Figure 7.1. For determination of postings, refer to Figures 7.3-7.6 for the proper posting vehicles.

(*If ASR is to be used)

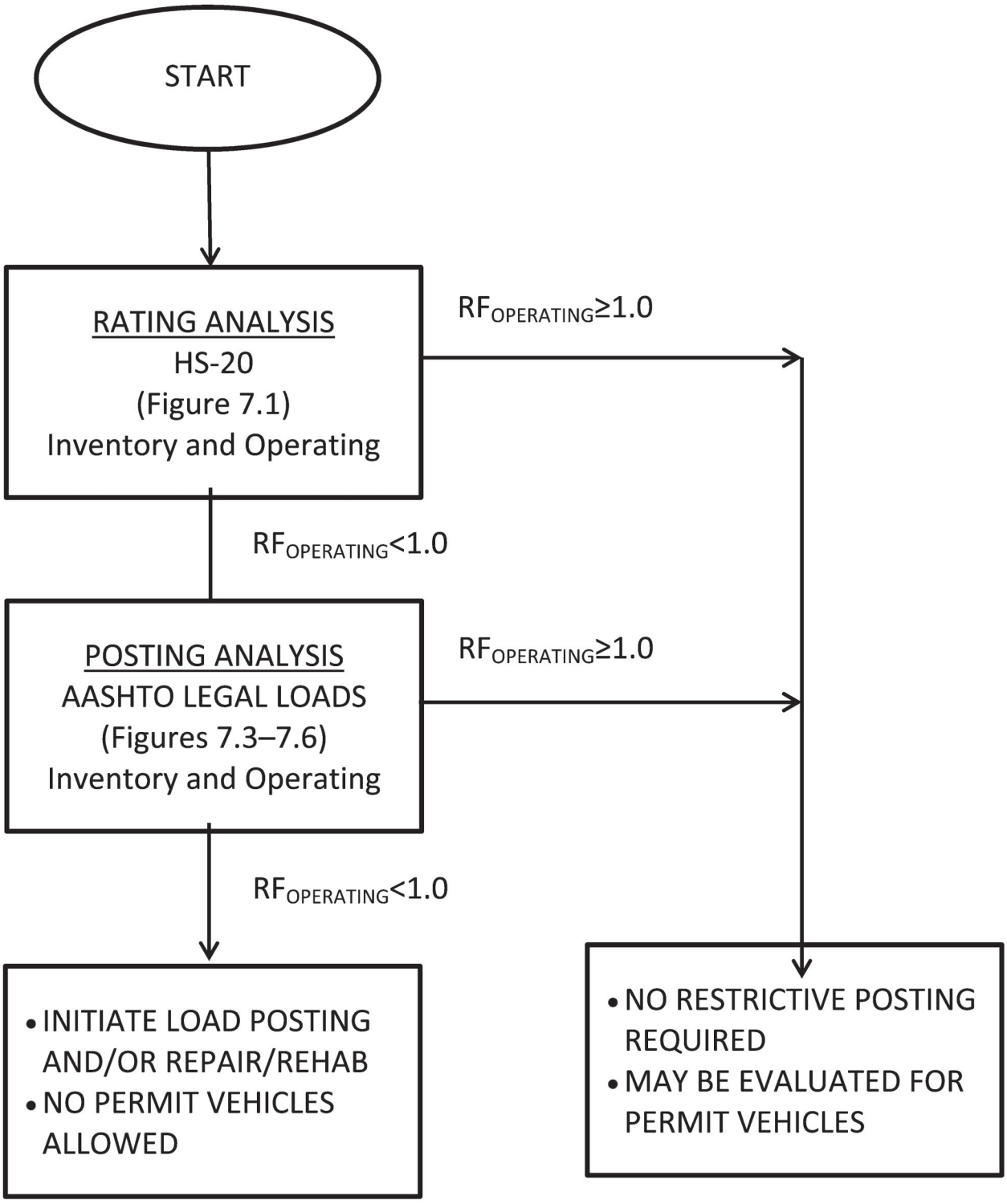


Figure A.1 Allowable Stress Rating and Load Factor Rating Flowchart

E.3. LOAD FACTOR RATING GUIDELINES

There is currently not a section that discusses the LFR method.

RECOMMENDED CHAPTER B LOAD FACTOR RATING (LFR) METHOD

All existing structures designed by the Allowable Stress Design (ASD) or Load Factor Design (LFD) methods may be rated utilizing the LFR method per the AASHTO *Manual for Bridge Evaluation, Second Edition*, Section 6B.

There are three potential checks to be made in LFR that are detailed in the flow chart shown in Figure A.1. For purposes of calculating the Inventory and Operating rating of the structure, the live load to be used shall be the HS-20 truck or lane loading as shown in Figure 7.1. For determination of postings, refer to Figures 7.3-7.6 for the proper posting vehicles.

E.4. LOAD AND RESISTANCE FACTOR RATING GUIDELINES

There is currently not a section that discusses the LRFR method.

RECOMMENDED CHAPTER C LOAD AND RESISTANCE FACTOR RATING (LRFR) METHOD

All existing structures designed by the Load and Resistance Factor Design (LRFR) method shall be rated utilizing the LRFR method per the AASHTO *Manual for Bridge Evaluation, Second Edition*, Section 6A. Existing structures designed by the Allowable Stress Design (ASD) or Load Factor Design (LFD) methods may also be rated utilizing the LRFR method per the AASHTO *Manual for Bridge Evaluation, Second Edition*, Section 6A.

The LRFR method is comprised of three distinct procedures: design load rating (first level evaluation), legal load rating (second level evaluation), and permit load rating (third level evaluation). The results of each procedure serve specific uses and also guide the need for further evaluation to verify bridge safety or serviceability. A flow chart outlining this process is shown in Figure C.1. For purposes of calculating the Inventory and Operating rating of the structure, the live load to be used shall be the HL-93 loading as shown in Figure 7.2. For determination of postings, refer to Figures 7.3-7.6 for the proper posting vehicles.

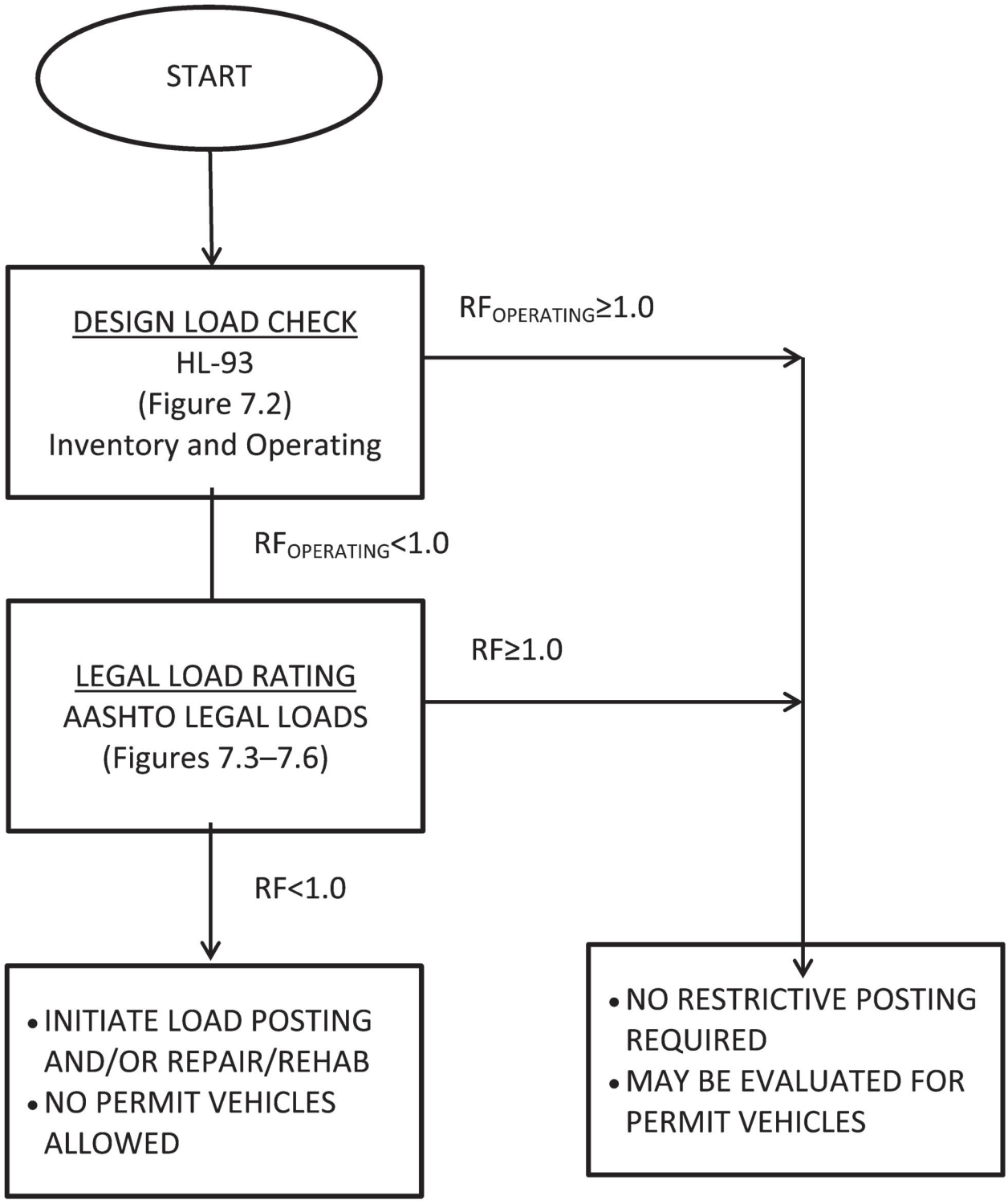


Figure C.1 Load and Resistance Factor Rating Flowchart

E.5 LEGAL VEHICLES

RECOMMENDED CHAPTER 7 VEHICLES

Load limits restrict how much weight can be carried on an axle, a single tire, a pair of tires, and on the vehicle or vehicle combination in total. Load limits are necessary for protecting bridges from structural weakening or fatigue, preventing unsafe conditions, and the early replacement of bridges.

Vehicles meeting Indiana Code Article 20, Size and Weight Restrictions, are considered legal loads and should be able to use any highway or bridge within the state (see Appendix A). Some routes, and many bridges, must be posted to protect them from possible damage. A posted bridge may restrict a legal load from use.

~~With the Federal Highway Administration's (FHWA's) adoption of the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design Specifications, the FHWA has issued a clarification of policy regarding the appropriate methodology and loads to be used in reporting operating and inventory rating data. It is necessary to accommodate and support Load and Resistance Factor Rating (LRFR), while continuing to accept Allowable Stress (AS) and Load Factor (LF) for the large inventory of in-service bridges that have been designed by a method other than Load and Resistance Factor Design (LRFD). It is not the intent of FHWA to mandate re-rating existing, valid bridge load ratings by LRFR.~~

~~Load ratings are to be reported to the National Bridge Inventory (NBI) annually. For bridges designed using LRFD using HL-93 loading, load ratings are to be computed and reported in tons and must indicate the rating method used. Load ratings shall be based on LRFR methods using HL-93 vehicular live load consisting of the design truck or design tandem and the design lane load.~~

~~For bridges designed using Allowable Stress Design (ASD) or Load Factor Design (LFD), load ratings are to be computed and reported in tons and must indicate the rating method used. Rating factors shall be based on LRFR methods using HL-93 loading or LFR methods based on the HS-20 vehicle. Bridges designed using LFD, and being rehabilitated, should be load-rated for the AASHTO LFD design vehicles.~~ Load ratings and respective locations should be entered into the Central Database for the following vehicles: H-20 Inventory (Truck and Lane); HS-20 Inventory & Operating (Truck and Lane); HS-25 Operating; Fatigue Truck Operating; and HL-93 Operating.

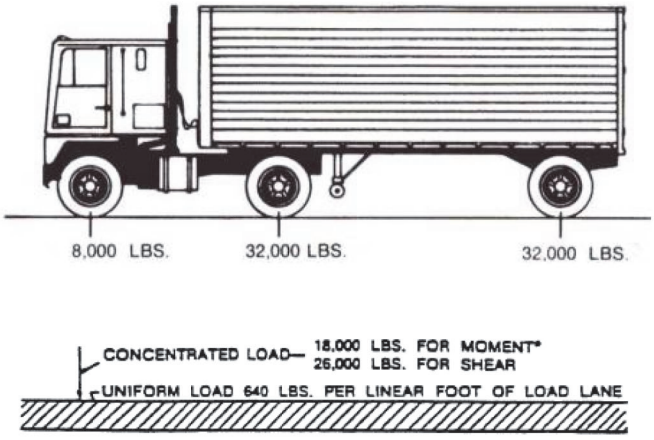


Figure 7.1 HS-20 Loading

*For the determination of maximum negative moments and interior reactions in continuous spans. For maximum negative moments, a second, equal weight concentrated load may be placed in one other span.

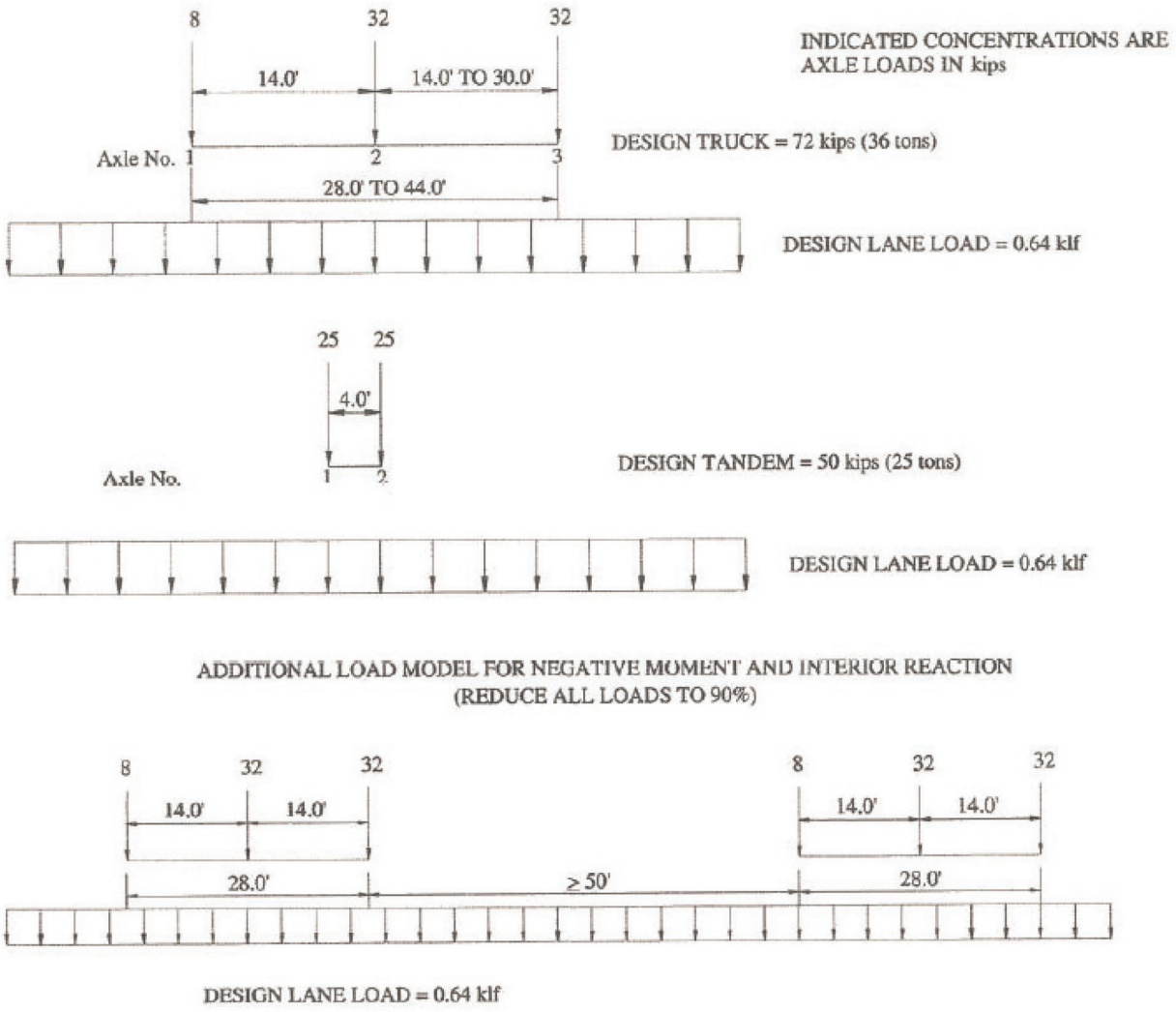


Figure 7.2 HL-93 Loading

SECTION 7.1 LEGAL LOADS

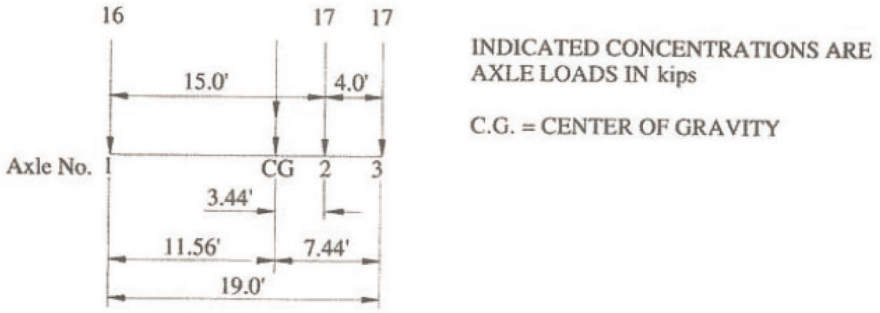
The live load to be used in the rating formula for posting considerations should be any of the three typical AASHTO legal trucks (Type 3, Type 3S2, Type 3-3) shown in Figure 7.3 or any of the four AASHTO specialized hauling vehicles (SU4, SU5, SU6, SU7) shown in Figure 7.6, per the AASHTO *Manual for Bridge Evaluation, Second Edition.*

As stated in the AASHTO *Manual for Bridge Evaluation, Second Edition*, for spans up to 200 ft, only the vehicle shall be considered present in the lane for positive moments. It is unnecessary to place more than one vehicle in a lane for spans up to 200 ft because the load factors have been modified for this possibility. For spans 200 ft in length or greater, the AASHTO Type 3-3 truck multiplied by 0.75 shall be analyzed combined with a lane load as shown in Figure 7.4. The lane load shall be taken as 0.2 klf in each lane and shall only be applied to those portions of the span(s) where the loading effects add to the vehicle load effects.

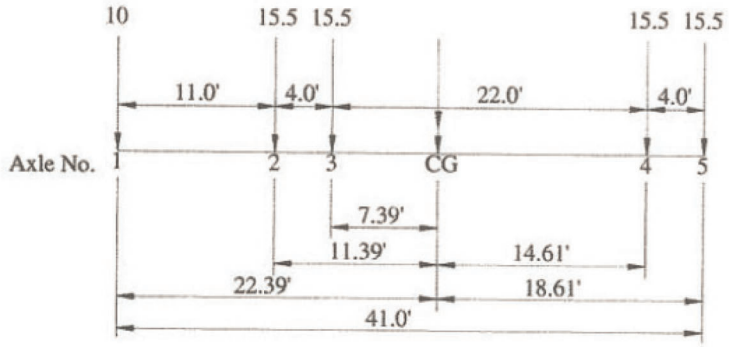
Also, for negative moments and reactions at interior supports, a lane load of 0.2 klf combined with two AASHTO Type 3-3 trucks multiplied by 0.75 shall be used. The trucks should be headed in the same direction and should be separated by 30 ft as shown in Figure 7.5. There are no span length limitations for this negative moment requirement.

~~Load limits restrict how much weight can be carried on an axle, a single tire, a pair of tires, and on the vehicle or vehicle combination in total. Load limits are necessary for protecting bridges from structural weakening or fatigue, preventing unsafe conditions, and the early replacement of bridges.~~

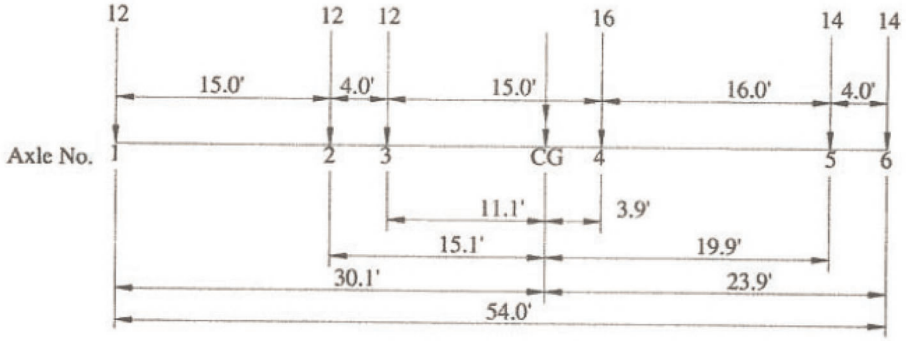
~~Vehicles meeting Indiana Code Article 20, Size and Weight Restrictions, are considered legal loads and should be able to use any highway or bridge within the state (see Appendix A). Some routes, and many bridges, must be posted to protect them from possible damage. A posted bridge may restrict a legal load from use. At this time, a bridge with a load capacity of H-20 is considered to best represent the state's load limit for the evaluation of the need for load posting.~~



Type 3 Unit; Weight = 50 kips (25 tons)



Type 3S2 Unit; Weight = 72 kips (36 tons)



Type 3-3 Unit; Weight = 80 kips (40 tons)

Figure 7.3 AASHTO Legal Trucks

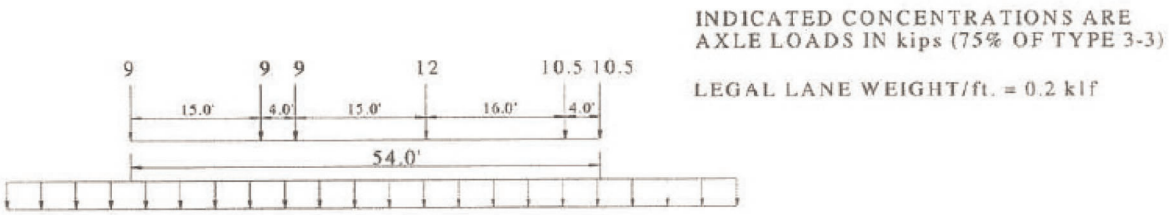


Figure 7.4 AASHTO Legal Load Model for Spans Greater than 200 ft

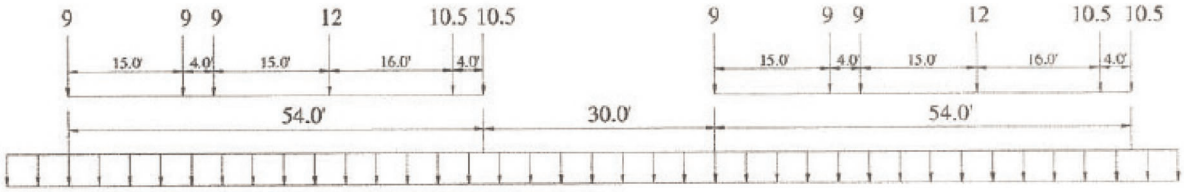


Figure 7.5 AASHTO Legal Load Model for Negative Moment and Interior Reactions

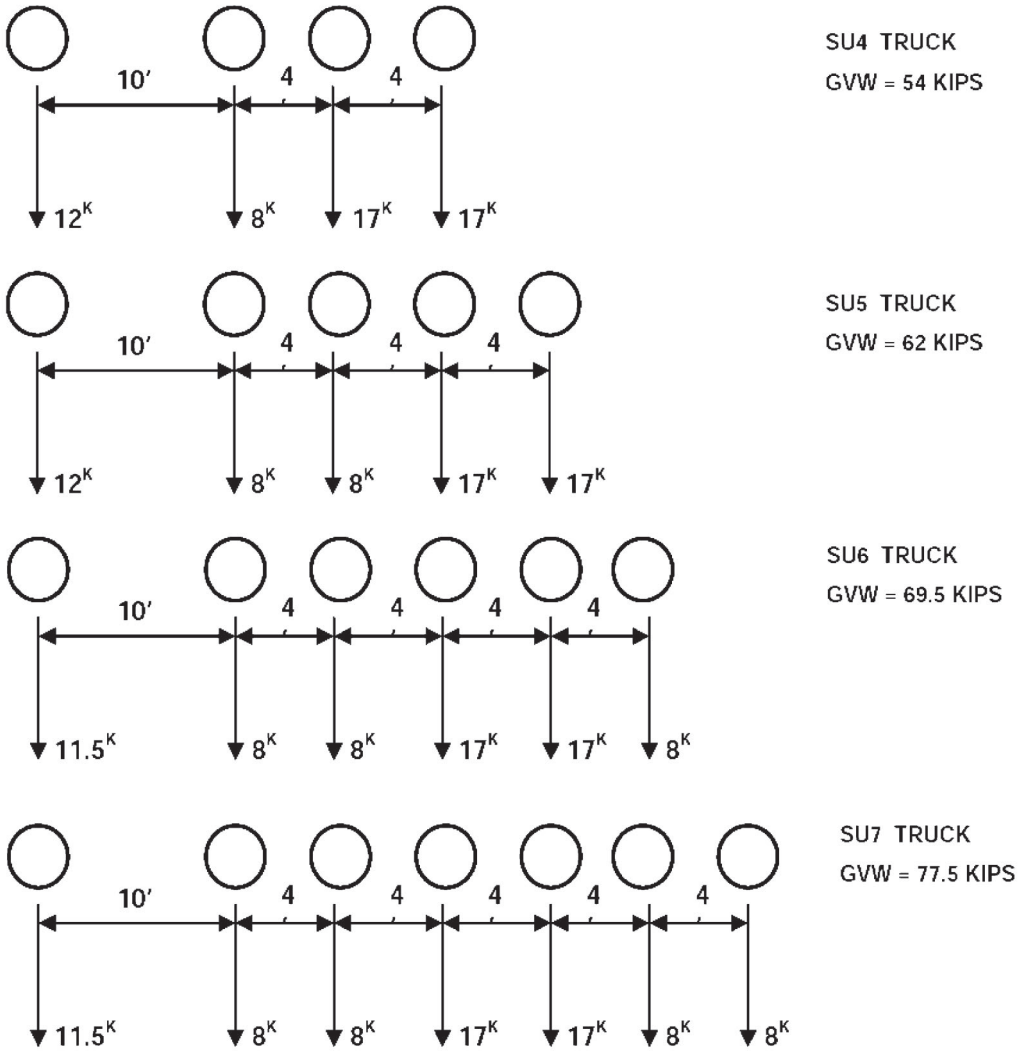


Figure 7.6 AASHTO Specialized Hauling Vehicles

E.6 POSTING GUIDELINES

RECOMMENDED CHAPTER 10 POSTING

In Indiana, a number of bridges cannot carry legal loads for various reasons. These include deterioration of load-carrying members, increases in dead loads from overlays or other alterations, and design for loads that were lower than what is currently legal. Since most of these bridges need to be kept open to traffic, load posting guidelines have been developed by the Indiana Department of Transportation (INDOT).

SECTION 10.1 POSTING GUIDELINES

The main objective of this guideline is to ensure the safety of the public. The guidelines must not conflict with Indiana vehicle and traffic laws, or federal regulations. This means that the following minimum criteria must always be met:

- Bridges shall never be posted for a load that will cause the operating stress level, as defined by American Association of State Highway and Transportation Officials (AASHTO), to be exceeded.
- The minimum load posting value is three tons. Bridges not capable of carrying a minimum gross live load weight of three tons must be closed.
- Load posting signs shall conform to the INDOT standards or the minimum requirements of the *Indiana Manual of Uniform Traffic Control Devices (INMUTCD) for Streets and Highways*.
- ~~Only one value may be used for posting. Silhouette signing is not recommended by INDOT.~~
- Bridge files should contain all pertinent posting information, along with photographs of the posting in place at both ends of the bridge.

Bridges which cannot carry the maximum weight for the vehicles described in Chapter 7 per the AASHTO *Manual for Bridge Evaluation, Second Edition* shall be posted using one of the standard signs shown in Figure 10.1, which should conform to the requirements of the Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices* (MUTCD). A bridge must be posted to restrict the gross vehicle weight and/or axle weight when the bridge can no longer safely support the maximum legal vehicle weight. The maximum weight restrictions for vehicles are described in the Indiana Code, Title 9, Article 20 (see Appendix A). The posting loads shall be determined by AASHTO *The Manual for Bridge Evaluation, Second Edition*, Equation 6B.4.1-2 (ASR and LFR) or AASHTO *The Manual for Bridge Evaluation, Second Edition*, Equation 6A.8.3-1 (LRFR). ~~INDOT's policy for load limit posting of bridges is based on a ton rating value. Any bridge that has a capacity of less than 16.0 tons for the H-20 rating vehicle at the inventory level shall be posted at the bridge site for the tonnage capacity. Most Indiana counties follow this policy. However, a bridge may also be posted at other load levels if deemed appropriate by the owner.~~ However, a bridge may also be posted at more restrictive load levels if deemed appropriate by the owner. Factors that may influence posting levels include traffic volume, traffic character, and the likelihood of overweight vehicles.

This posting policy is official for state-owned bridges only. However, many local owners also follow these procedures to set posting values. The Load Rating Team Leader notifies the bridge owner of posting requirements. INDOT reserves the right to withhold federal funding if bridge owners are not posting in accordance with this posting policy.

Posting bridges for load limit is a serious matter. Doing so can create a hardship on the motoring public and industry in the vicinity of the bridge. Bridges that rate low using Allowable Stress (AS) should be re-rated using Load Factor (LF) or Load and Resistance Factor Rating (LRFR) to determine if the bridge can accommodate higher loads based on currently accepted code criteria. Similarly, bridges that rate low using LF should be re-rated using LRFR prior to posting. To ensure that posting is justified, an inspection should be conducted by the Inspection Team Leader to visually confirm the condition, measurements, and other properties of the bridge. When appropriate, a more in-depth analysis of live load distribution should be conducted to assure that the capacity is truly valid.

A one-lane alternative may be considered when evaluating for posting. Normally a bridge will be rated for the normal number of traffic lanes it is capable of carrying; however, if the capacity is less than 16 tons, the bridge may be checked for a reduced number of lanes. Reducing the number and locations of loaded lanes, and restricting lanes with barrels or stop lights, can keep a bridge from being posted with a weight restriction. Reference the INDOT Bridge Reporting for Appraisal and Greater Inventory (BRAGI) Coding Guide for coding of this situation.

SECTION 10.2 POSTING PROCEDURE

If posting is required or warranted for state, county, toll road, or other local agency bridges, the signs should conform and be installed in accordance with the INMUTCD. Signs should be legible from a distance of no less than 50 feet. Additional advance signage shall be placed at the intersection with the last state road prior to the bridge. Advance signage shall be located as necessary to provide prohibited vehicles the opportunity to detour.

Signs must be maintained during the life of the bridge or until repairs have been made to remove the restriction. Postings or closings on state routes should be done according to INDOT's current Bridge Restriction or Closure Protocol (see Appendix B). It is recommended that counties, the toll road, and other local agencies follow a similar protocol. An official posting/closure letter, signed by a designated official, should be added to the bridge file. The gross vehicle weight and/or axle weight allowed should be indicated on signs at each end of the bridge. The R12-5 silhouette sign shown in Figure 10.1 is recommended as it allows significantly heavier loads to use the bridge. The top silhouette represents the AASHTO Type 3 legal truck and the four AASHTO specialized hauling vehicles, the middle silhouette represents the AASHTO Type 3S2 legal truck, and the bottom silhouette represents the AASHTO Type 3-3 legal truck. The R12-1 sign shown in Figure 10.1 may be used where significant weight restrictions exist. The single gross tonnage value shown represents the lowest of all of the legal loads. ~~Posting of specific load limits should be accomplished using an R12-1 sign, containing the legend "WEIGHT LIMIT" on the top two lines and the applicable weight limit on the bottom two lines. The weight limits shall be shown as "X TONS."~~ Weight limit signage shall be used to indicate restrictions pertaining to total vehicle weight, including cargo. Failure to post bridges that have capacities less than the posting value can result in a loss of federal bridge funds.

Posting of a bridge closure may be accomplished by the use of an R11-2, "ROAD CLOSED" sign. In addition to signage, significant non-moveable barriers shall be placed at each end of the closed bridge, restricting crossing. A permanent barricade shall be built across both ends of the bridge to prevent vehicles from crossing.

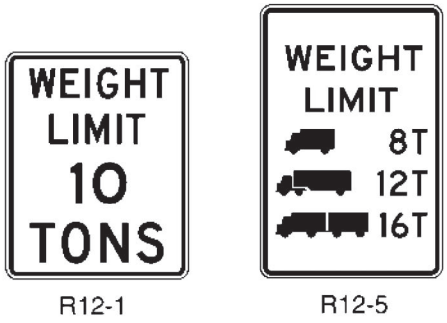


Figure 10.1 Common Restrictive Weight Limit Signs

In order to document proper posting of a bridge, photos of the posting shall be taken at each end of the bridge. Photos shall be submitted when they are installed, and at each inspection. An updated Structure Inventory and Appraisal (SI&A) Report shall be submitted and the Central Database shall be updated immediately following any load rating or posting change. These are major National Bridge Inspection Standards (NBIS) compliance review items and the use of federal bridge funds can be suspended for noncompliance.

About the Joint Transportation Research Program (JTRP)

On March 11, 1937, the Indiana Legislature passed an act which authorized the Indiana State Highway Commission to cooperate with and assist Purdue University in developing the best methods of improving and maintaining the highways of the state and the respective counties thereof. That collaborative effort was called the Joint Highway Research Project (JHRP). In 1997 the collaborative venture was renamed as the Joint Transportation Research Program (JTRP) to reflect the state and national efforts to integrate the management and operation of various transportation modes.

The first studies of JHRP were concerned with Test Road No. 1—evaluation of the weathering characteristics of stabilized materials. After World War II, the JHRP program grew substantially and was regularly producing technical reports. Over 1,500 technical reports are now available, published as part of the JHRP and subsequently JTRP collaborative venture between Purdue University and what is now the Indiana Department of Transportation.

Free online access to all reports is provided through a unique collaboration between JTRP and Purdue Libraries. These are available at: http://docs.lib.purdue.edu/jtrp

Further information about JTRP and its current research program is available at: http://www.purdue.edu/jtrp

About This Report

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